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# THE JOURNAL OF THE ALABAMA ACADEMY OF SCIENCE



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COVER PHOTOGRAPH: Female labrador retriever dog. *Neospora caninum* is a newly recognized protozoan parasite that causes disease in dogs and other animals. In dogs, severe disease occurs in transplacentally infected puppies despite the fact that their mothers appear normal. These puppies have infection and inflammation of most skeletal muscles, heart, brain, spinal cord and nerves. Many develop hindlimb paralysis. The paralysis may become progressive and move to the front limbs and face. Most pups in a litter are infected and many die. It is thought that a mother dog can pass the infection to more than one litter. Abortions and neonatal paralysis due to *N. caninum* have also been reported in cattle, sheep, and horses. Presently, the complete life cycle of the parasite is not known. Researchers at Auburn University and the USDA, Zoonotic Diseases Laboratory, are studying the biology of this parasite. They are developing mouse models of pathogenicity (see article this issue) and maternal transmission, diagnostic tests, and testing drugs against the parasite. Photograph of "Chelsea" courtesy of Joy Bowles.

Dr. David S. Lindsay and Dr. Byron L. Blagburn are from the Department of Pathobiology, College of Veterinary Medicine, Auburn University, Alabama. Dr. J. P. Dubey is from the USDA, Zoonotic Disease Laboratory, Beltsville, Maryland.



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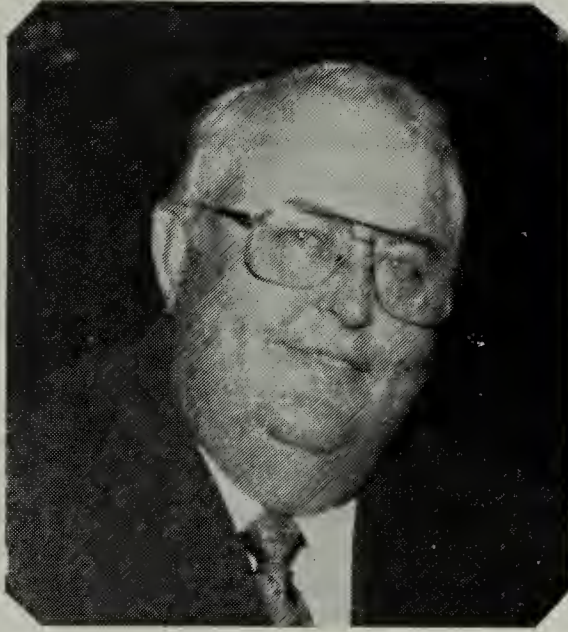
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## IN MEMORIAM



Dr. William H. "Bill" Mason  
June 16, 1936 - November 25, 1990

Dr. Bill Mason, an extremely active and dedicated member of the Alabama Academy of Science, died Sunday, November 25, 1990 while visiting family in Kingsville, Texas.

During his years of Academy membership, Dr. Mason served on numerous AAS committees. At the time of his death, he was completing his 12th year as Editor of the *Journal of the Alabama Academy of Science* while simultaneously serving as the Coordinator of the 1990-91 State of Alabama Science Olympiad and the Regional Coordinator of the 1990-91 State Science Fair. As Editor, Dr. Mason made many improvements in the J.A.A.S., including the use of attractive, color photographs on the cover.

Dr. Mason was Associate Dean of Auburn University's College of Sciences and Mathematics. He joined the Auburn University faculty in 1966 as an Assistant Professor in the Department of Zoology-Entomology and in 1987, was named Associate Dean for Academic Affairs. He was named an Alumni Professor in 1986 and held a teaching appointment in the Department of Zoology and Wildlife Science.

Dr. Mason helped establish the freshman biology program which serves more than 6,000 students annually and served as coordinator of the program until 1987. For more than 20 years he taught freshman biology and was the author or coauthor of two biology textbooks, eight laboratory manuals and study guides and 20 articles in refereed journals. In 1989, Dr. Mason received the "Professional Employee of the Year" award from the East Alabama Committee on Employment of People with Disabilities.

William H. "Bill" Mason

For the past two years, Dr. Mason served as the campus coordinator for the United Way of Lee County and for many years was active with the Red Cross Blood Drives on campus. In 1984, he volunteered to serve Auburn High School as an advisor in the development of a year-long honors, or advanced, course in biology.

Dr. Mason served one year as an infantry officer with the 101st Airborne Division of the U.S. Army. Prior to joining AU, he taught general science and biology for four years in Arkansas public schools. He was a graduate of Arkansas Polytechnic College and received his Masters and Doctoral degrees from the University of Georgia.

For many of us members of the Academy, the phrase "gone, but not forgotten" holds a truly significant meaning when applied to our friend and colleague, Bill Mason. He certainly made a difference, and he will continue to do so for a long, long time through the countless lives that he touched.



## BILL MASON

*When I heard Bill died  
it wasn't real.  
I thought  
someone would tell me that.*

*But they didn't.  
I went to another room  
and cried  
as I haven't since I can remember.*

*Bill and I shared a lot.  
We cut wood together.  
We went to the races.  
We told jokes.*

*We laughed.  
A lot.  
We never cried together,  
but we did.*

*Bill wasn't disabled.  
His wheelchair was  
just another car.  
He's free now.*

*There's a sharp knock on the door.  
"Come in."  
"It's me, Ivan.  
Don't want to take up your time."*

*Take up my time?!  
You can take up my time any time you want.  
I'll miss that  
dearly.*

*Fishing with crickets  
Fishing for bream  
Laughing  
Fishing with Mason.*

*How can we make it without Bill?  
"Come on, Ivan,  
I'm dispensable.  
You'll do fine."*

*Bill left Auburn on Wednesday.  
He's not coming back.  
But he never really left.  
He's here, now.*

*Ivan Legg, Auburn, Alabama, November 25, 1990*

Ivan Legg is Dean of the College of Sciences and Mathematics at Auburn University where Dr. Mason served as Associate Dean for Academic Affairs

THE  
WILLIAM H. MASON  
MEMORIAL  
SCIENCE TEACHER FELLOWSHIP  
PROGRAM

The Alabama Academy of Science, in memory of Dr. William H. "Bill" Mason, wishes to recognize his many contributions to the Academy, the field of science and to science education. Therefore, the Academy announces that its teacher education fellowship will be named the "William H. Mason, Memorial, Science Teacher Fellowship." Anyone wishing to contribute to this memorial fellowship, may send a donation to either the President or Executive Director of the Academy. The following is a brief description of the Fellowship:

AWARDS

Recognizing the need for improved science teaching at all levels, the Alabama Academy of Science has established the William H. Mason, Memorial, Science Teacher Fellowship to assist scientifically trained students to enter the teaching profession. This graduate student fellowship is in the amount of \$2,000 for one year (non-renewable), and is tenable at any institution in the state of Alabama offering a teacher certification program. Awardees may choose to specialize in any area Kindergarten through the 12th grade (K-12). Selection will be based on the extent to which the applicant shows promise for incorporating quality science instruction in his or her classroom.

ELIGIBILITY

Students who will have earned a B.S. or B.A. degree, prior to the expected Fall graduate enrollment, are invited to apply for the William H. Mason, Memorial, Science Teacher Fellowship. Applicants must have the equivalent of a minor or major in a natural science, and must be applicants for a program leading to certification in teaching at any level K-12. Recipients will be required to teach in the state of Alabama for at least one year following completion of the degree program for which the award is given.

PROCEDURES

Fellowship application forms are normally sent to all post-secondary science and education departmental offices in the State of Alabama. Interested students should contact these departments, or write to:

Executive Director  
Alabama Academy of Science  
208 Rockaway Road  
Birmingham, AL 35209

CHARACTERIZATION OF A *NEOSPORA CANINUM* (PROTOZOA:<sup>1</sup>  
APICOMPLEXA) ISOLATE (NC-3) IN MICE

David S. Lindsay, J. P. Dubey\*, and Byron L. Blagburn  
Department of Pathobiology  
College of Veterinary Medicine  
Auburn University, AL 36849-5519

ABSTRACT

*Neospora caninum* Dubey, Carpenter, Speer, Topper, and Uggla, 1988 is a newly recognized protozoan pathogen of dogs. The response of methylprednisolone acetate (MPA) treated mice to infection with tachyzoites of the NC-3 isolate of *N. caninum* was examined. Disease and deaths occurred in mice that were subcutaneously or intraperitoneally inoculated with tachyzoites. Tachyzoites were not infectious following oral inoculation as judged by lack of disease and absence of parasites. *In vitro* studies demonstrated that tachyzoites were killed by exposure to pepsin-HCl solution but not 1% trypsin solution. Tissue cysts were present in the brains of mice inoculated 13 months previously, and the bradyzoites in the tissue cysts were still infectious for mice and cell cultures.

*Neospora caninum* Dubey, Carpenter, Speer, Topper, and Uggla, 1988, is a newly recognized protozoal pathogen (Dubey, 1990; Dubey et al., 1988a) structurally similar to *Toxoplasma gondii* Nicolle and Manceaux, 1909. Until recently *N. caninum* was confused with and misdiagnosed as *T. gondii* (Lindsay and Dubey, 1989a; Lindsay et al., 1990). *Neospora caninum* causes severe, often fatal, disease in transplacentally infected dogs. Affected dogs develop ascending paralysis, encephalitis, polyradiculoneuritis, and polymyositis (Bjerkas et al., 1984; Cummings et al., 1988, Dubey et al., 1988a, 1988b, 1990a, Uggla et al., 1989). A bitch may transmit the infection to several successive litters (Cummings et al., 1988; Dubey et al., 1988b, 1990a). Congenital infections with *N. caninum* also have been observed in naturally infected calves, lambs, and foals indicating that the host range is not confined to dogs (Dubey et al., 1989, 1990b, 1990c; Dubey and Porterfield, 1990). Experimental studies have documented transplacental transmission in dogs and cats (Dubey and Lindsay, 1989a, 1989b) and induced abortions in sheep (Dubey and Lindsay, 1990). Abortions have also been seen in naturally infected cattle (Shivaprased et al., 1989; Thilsted and Dubey, 1989).

The complete life cycle of *N. caninum* is not known. Tachyzoites, rapidly multiplying stages, occur in almost any cell in the body and cause tissue damage. Bradyzoites are slowly multiplying stages that are found

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<sup>1</sup>Manuscript received 29 October 1990; accepted 18 December 1990.

\*U.S. Department of Agriculture, Zoonotic Diseases Laboratory, BARC-East, Beltsville, Maryland 20705.

in tissue cysts located in the central nervous system. Infections in ruminants and foals suggest that an oocyst stage is present in the life cycle, but none has been found in experimentally infected animals examined to date (Dubey, 1990).

*Neospora caninum* has been isolated from congenitally infected dogs from 3 different bitches (Dubey et al., 1988b, Hay et al., 1990; Lindsay et al., 1990). The pathogenicity of 2 of the isolates (NC-1 isolate and NC-2 isolate) have been examined in mice (Lindsay and Dubey, 1989c, 1990b). The present study was conducted to determine the effects of route of inoculation on infectivity and pathogenicity of the NC-3 isolate of *N. caninum* for mice and to examine longevity of tissue cysts in mice.

#### MATERIALS AND METHODS

##### *Maintenance of parasites and preparation of inocula*

Tachyzoites of the NC-3 isolate of *N. caninum* are maintained by serial passage in bovine monocyte (BM) cell culture (Lindsay and Dubey, 1989a) or African Green Monkey kidney cells (Vero) ATCC CCL 81, Rockville, MD). For these studies, host cells were grown in 25 cm<sup>2</sup> plastic tissue culture flasks in RPMI-1640 medium supplemented with 10% (v/v) fetal bovine serum, 100 u/ml penicillin G, 100 ug/ml dihydrostreptomycin (GIBCO, Grand Island, NY) and  $5 \times 10^{-2}$  mM 2-mercaptoethanol (Sigma Chemical Company, St. Louis, MO). Cell cultures were maintained in identical media in which the fetal bovine serum was lowered to 2% (v/v). Cell cultures were incubated at 37 C in a 95% air- 5% CO<sub>2</sub> atmosphere. Tachyzoites were obtained from host cells by scraping the infected monolayer off the plastic growth surface which ruptures most infected host cells. Tachyzoites were then separated from host cells and cellular debris by passage through a 3 um polycarbonate filter. Tachyzoites were then counted in a hemocytometer and the concentration of tachyzoites was adjusted so that 1 ml contained  $2 \times 10^5$  tachyzoites for subcutaneous (SC) inoculations or that 0.5 ml contained  $2 \times 10^5$  tachyzoites for oral or intraperitoneal (IP) in inoculations.

##### *Infection and examination of mice*

Outbred female Swiss-Webster mice (body weight, 20-25 g) were used for experimental inoculations. All mice inoculated with *N. caninum* tachyzoites received 4 mg methylprednisolone acetate (MPA) (The Upjohn Company, Kalamazoo, MI) intramuscularly (IM) on day 7 prior to inoculation and on the day of inoculation. The MPA was used to increase the susceptibility of mice to *N. caninum* infections (Lindsay and Dubey, 1989c). Three groups of 10 mice each were inoculated with tachyzoites, SC (Group 1), IP (Group 2), and orally (Group 3). Control groups consisted of 5 mice that were given MPA (Group 4) and 5 mice that were not given MPA or tachyzoites (Group 5).

Tissues were collected for histologic examination from mice killed while moribund, mice judged to be recently dead, or mice killed when the study was terminated 28 days postinoculation (PI). The brain, lungs,



## Characterization of a *Neospora caninum* isolate in mice

liver, spleen, pancreas, kidneys, adrenal glands, tongue, heart, and thigh muscle from clinically infected mice were fixed in 10% neutral buffered formalin solution. Representative sections were processed for light microscopic examination and stained with hematoxylin and eosin. Only the brain was collected and examined histologically from control mice and from mice that were clinically normal throughout the study. Fresh smears were made from the lungs of mice that died and examined unstained for tachyzoites by light microscopy. Squash preparations were made from the brains of mice with gross brain lesions and examined, unstained, for tachyzoites or tissue cysts.

Blood was collected from the retro-orbital plexus of mice that survived the 28 day PI observation period. Sera were examined for anti-*N. caninum* antibodies in an indirect immunofluorescent antibody (IFA) assay (Lindsay and Dubey, 1989c).

### *Long term survival of tissue cysts in mice*

To examine long term survival of *N. caninum* tissue cysts in mice, five mice were given 2 mg MPA (-7 and 0 days PI) and inoculated SC with  $1 \times 10^5$  tachyzoites of the NC-3 isolate (Group 6). The mice were given sodium sulfadiazine (1 mg/ml) in drinking water (Lindsay and Dubey, 1990a) on days 7 to 24 PI. This was done to treat the acute infections and to produce chronic infections in which tissue cysts would be present. One mouse died of acute neosporosis 8 days PI; the 4 other mice survived the initial infection and were killed 13 months PI. Squash preparations were made from the brains and examined for tissue cysts. The remaining portions of all 4 brains were mixed together in approximately 2 ml Hanks' balanced salt solution (HBSS) and disrupted by passage through a syringe equipped with progressively smaller gauge needles (final gauge = 25). The mixture was divided into 2 equal portions. One portion was resuspended in HBSS and SC inoculated into 4 mice (Group 7) and inoculated onto uninfected cell cultures, whereas the other portion was subjected to pepsin-HCl digestion (Jacobs et al., 1960) for 10 minutes at 37 C. The pepsin-HCl digested mixture was washed free of acid in maintenance medium and SC inoculated into 4 mice (Group 8) and onto uninfected cell cultures. All mice used in this portion of the study had been given 4 mg MPA IM -1 and 7 days PI. Blood was collected from all surviving mice 28 days PI and the sera examined for anti-*N. caninum* antibodies using the IFA assay.

### *Cell culture assay for effects of pepsin-HCl solution and trypsin solution on tachyzoites*

Parasites in orally acquired infections must survive passage through the stomach and exposure to digestive enzymes. To examine the effect of digestive enzymes on tachyzoites of the NC-3 isolate, infected monolayers were scraped from the flasks, pelleted by centrifugation and exposed to pepsin-HCl (pH 0.8) solution (Jacobs et al., 1960) or 1% (w/v) trypsin (pH 5.5) solution at 37 C for 30 min. The samples were then washed three times in cell culture maintenance medium and inoculated onto uninfected BM and Vero cells. The cell cultures were examined with an inverted microscope 2 or 3 times weekly for 4 weeks to determine if infections were present.



## RESULTS

### *Characterization of the NC-3 isolate*

Clinical signs of disease were seen only in mice in Groups 1 and 2. These mice developed rough hair coats 5 to 7 days PI. Some of the Group 2 mice appeared to develop ascites. All of the SC inoculated mice (Group 1) died between days 10 to 16 PI. Pneumonia was the most common and pronounced gross lesion observed in these mice, and tachyzoites were present in smears of the lungs. Of the 10 IP inoculated mice (Group 2), 8 died 6 to 8 days PI, 1 died 17 days PI, and 1 was killed on day 17 PI. The IP inoculated mice that died early in the infection had small amounts of ascites fluid. This fluid contained few tachyzoites. Microscopic lesions seen in the SC and IP inoculated mice were similar to those described previously (Lindsay and Dubey, 1989c, 1990b). Myocarditis, myositis, hepatitis, pancreatitis, and pneumonia were present in most mice examined 7 to 10 days PI and encephalitis, myocarditis, myositis, and pneumonia were seen in most mice examined 7 to 10 days PI and encephalitis, myocarditis, myositis, and pneumonia were in most mice examined 10 to 17 PI. Muscle lesions were often mineralized, and pancreatitis was more severe in IP inoculated mice. Tachyzoites were usually scarce in lesions. None of the mice inoculated orally developed clinical signs. However, one orally inoculated mouse was found dead on day 9 PI; no gross lesions or parasites were detected found in its tissues, but examination of its tissues indicated that bacterial septicemia was present. None of the control mice in Groups 4 and 5 developed clinical signs or died. The remaining orally inoculated mice and the 2 groups of control mice had no parasites or lesions in tissue sections of their brains. No anti-*N. caninum* antibodies were present in sera from control or orally inoculated mice.

### *Long term survival of tissue cysts*

Two of the 4 mice in group 6 examined 13 months PI had tissue cysts (Fig. 1) present in brain squashes. The 7 tissue cysts examined had diameters that ranged from 32 to 45  $\mu\text{m}$  (mean = 37.8  $\mu\text{m}$ ) and had a thick tissue cyst wall characteristic of *N. caninum*. Cell cultures inoculated with digested and undigested brain preparations became infected. Two mice in group 7 that were inoculated with undigested brain mixture died. One died 15 days PI and the other died 23 days PI; both were positive for tachyzoites of *N. caninum*. The remaining 2 mice in group 7 were positive for antibodies to *N. caninum* in the IFA assay. None of the mice in group 8 inoculated with digested brain mixture died; all were positive for antibodies to *N. caninum* in the IFA assay.

### *Effects of digestive enzymes on tachyzoites*

Exposure of tachyzoites to pepsin-HCl solution prevented infectivity for cell cultures, whereas exposure of tachyzoites to 1% trypsin solution did not prevent infection of cell cultures.

## Characterization of a *Neospora caninum* isolate in mice

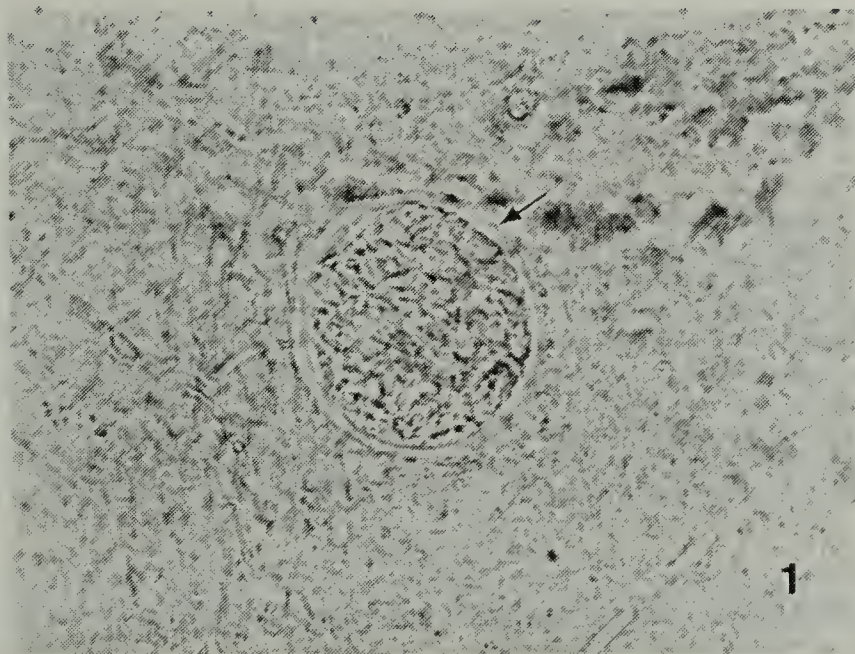


Figure 1. *Neospora caninum* tissue cyst in a squash preparation from the brain of a mouse infected SC 13 months previously with tachyzoites of the NC-3 isolate. Note the thick tissue cyst wall (arrow). X 750.

### DISCUSSION

The present study demonstrates that SC or IP inoculation of the NC-3 isolate into MPA treated mice results in lethal infection. This suggests that MPA treatment increases the susceptibility of mice to the NC-3 isolate, because in a previous study no clinical signs of disease were seen in mice inoculated SC with the NC-3 isolate and not treated with MPA (Lindsay et al., 1990). The responses of mice to SC or IP inoculation with the NC-3 isolate were similar to those of mice SC or IP inoculation with the NC-1 and NC-2 isolates (Lindsay and Dubey, 1990b). The NC-1 isolate appears to be more pathogenic for mice than either the NC-2 or NC-3 isolates because MPA treated mice died sooner when inoculated SC or IP with this isolate (Lindsay and Dubey, 1990b, present study). The pathogenicity of the NC-2 and NC-3 isolates appear to be similar.

In the present study, the NC-3 isolate was not infectious for mice following oral inoculation. In contrast tachyzoites of the NC-1 and NC-2 isolates were shown to be infectious for mice following oral inoculation in a previous study (Lindsay and Dubey, 1990b). The oral infectivity of tachyzoites of the NC-1 and NC-2 isolates in the previous study was puzzling because in vitro studies indicated that tachyzoites of these isolates were killed in pepsin-HCl solution, which simulates passage through the stomach. It was suggested (Lindsay, and Dubey, 1990b) that trauma to the oral cavity and/or esophagus might occur during inoculation and that the tachyzoites may enter the body through these damaged areas, rather than by surviving passage through the stomach. Results of oral

inoculations and effects of pepsin-HCl solution on tachyzoites in the present study demonstrate that tachyzoites of the NC-3 isolate do not survive passage through the stomach.

In the study, *N. caninum* tissue cysts remained present and viable in mouse brains for up to 13 months. The tissue cysts were still relatively small in size. Chronically infected mice can serve as a source of tissue cysts. It is well known that continuous passage in cell culture or frequent passage in mice alters the biology of *T. gondii* so that the parasite loses the ability to produce oocysts in cats (Frenkel et al., 1976; Lindsay et al., 1991). Continuous passage of *N. caninum* in cell culture will probably alter its biology in a similar way making studies on definitive hosts impossible. However, alterations in biological properties perhaps could be avoided by maintaining a source of chronically infected mice with tissue cysts present in their brains.

#### ACKNOWLEDGEMENTS

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#### LITERATURE CITED

- Bjerkas, I., S. F. Mohn, and J. Presthus. 1984. Unidentified cyst-forming sporozoon causing encephalomyelitis and myositis in dogs. *Z. Parasitenkd.* 70: 271-274.
- Cummings, J. F., A. de Lahunta, M. M. Suter, and R. H. Jacobson. 1988. Canine protozoan polyradiculoneuritis. *Acta Neuropathol.* 76: 46-54.
- Dubey, J. P. 1990. *Neospora caninum*: a look at a new *Toxoplasma*-like parasite of dogs and other animals. *Compend. Cont. Ed. Pract. Vet.* 12: 653-663.
- Dubey, J. P., and D. S. Lindsay. 1989a. Transplacental *Neospora caninum* infections in dogs. *Am. J. Vet. Res.* 50: 1578-1579.
- Dubey, J. P., and D. S. Lindsay. 1989b. Transplacental *Neospora caninum* infections in cats. *J. Parasitol.* 75: 765-771.
- Dubey, J. P., and D. S. Lindsay. 1990. Abortions in sheep due to *Neospora caninum*. *J. Vet. Diagn. Invest.* 2: 230-233.
- Dubey, J. P., and M. L. Porterfield. 1990. *Neospora caninum* in an aborted equine fetus. *J. Parasitol.* 76: 732-734.
- Dubey, J. P., J. L. Carpenter, C. A. Speer, M. J. Topper, and A. Uggla. 1988a. Newly recognized fatal protozoal disease of dogs. *J. Am. Vet. Med. Assoc.* 192: 1269-1285.



Characterization of a *Neospora caninum* isolate in mice

- Dubey, J. P., A. L. Hattal, D. S. Lindsay, and M. J. Topper. 1988b. Neonatal *Neospora caninum* infection in dogs: isolation of the causative agent and experimental transmission. J. Am. Vet. Med. Assoc. 193: 1259-1263.
- Dubey, J. P., C. W. Leathers, and D. S. Lindsay. 1989. *Neospora*-like protozoon associated with fatal myelitis in newborn calves. J. Parasitol. 75: 146-148.
- Dubey, J. P., A. Koestner, R. C. Piper. 1990a. Repeated transplacental transmission of *Neospora caninum* in dogs. J. Am. Vet. Med. Assoc. 197: 857-86.
- Dubey, J. P., W. J. Heartly, D. S. Lindsay, and M. J. Topper. 1990b. Fatal congenital *Neospora caninum* infection in a lamb. J. Parasitol. 76: 127-130.
- Dubey, J. P., S. Miller, D. S. Lindsay, and M. J. Topper. 1990c. *Neospora caninum*-associated myocarditis and encephalitis in an aborted calf. J. Vet. Diagn. Invest. 2:66-69.
- Frenkel, J. K., J. P. Dubey, and R. L. Hoff. 1976. Loss of stages after continuous passage of *Toxoplasma gondii* and *Besnoitia jellisoni*. J. Protozool. 23: 421-424.
- Hay, W. H., L. G. Shell, D. S. Lindsay, and J. P. Dubey. 1990. Diagnosis and treatment of *Neospora caninum* in a dog. J. Am. Vet. Med. Assoc. 197: 87-89.
- Jacobs, L., J. S. Remington, and M. L. Melton. 1960. The resistance of the encysted form of *Toxoplasma gondii*. J. Parasitol. 46: 11-21.
- Lindsay, D. S., and J. P. Dubey. 1989a. Immunohistochemical diagnosis of *Neospora caninum* in tissue sections. Am. J. Vet. Res. 50: 1981-1983.
- Lindsay, D. S., and J. P. Dubey. 1989b. In vitro development of *Neospora caninum* (Protozoa: Apicomplexa) from dogs in cell cultures. J. Parasitol. 75: 163-165.
- Lindsay, D. S., and J. P. Dubey. 1989c. *Neospora caninum* (Protozoa: Apicomplexa) infections in mice. J. Parasitol. 75: 772-779.
- Lindsay, D. S., and J. P. Dubey. 1990a. Effects of sulfadiazine and amprolium on *Neospora caninum* (Protozoa: Apicomplexa) infections in mice. J. Parasitol. 76: 177-179.
- Lindsay, D. S., and J. P. Dubey. 1990b. Infections in mice with tachyzoites and bradyzoites of *Neospora caninum* (Protozoa: Apicomplexa). J. Parasitol. 76: 410-413.
- Lindsay, D. S., and J. P. Dubey. 1990c. *Neospora caninum* (Protozoa: Apicomplexa) infections in rats. Can. J. Zool. 68: 1595-1599.

Lindsay, Dubey, and Blagburn

- Lindsay, D. S., B. L. Blagburn, and J. P. Dubey. 1990. Infection of mice with *Neospora caninum* (Protozoa: Apicomplexa) does not protect against challenge infection with *Toxoplasma gondii*. Infect. Immun. 58: 2699-2700.
- Lindsay, D. S., J. P. Dubey, B. L. Blagburn, and M. Toivio-Kinnucan. 1991. Examination of tissue cyst formation by *Toxoplasma gondii* in cell cultures using bradyzoites, tachyzoites, and sporozoites. J. Parasitol. (in press).
- Shivaprasad, H. L., R. Ely, and J. P. Dubey. 1989. A *Neospora*-like protozoon found in an aborted bovine placenta. Vet. Parasitol. 34: 145-148.
- Thilsted, J. P., and J. P. Dubey. 1989. Neosporosis-like abortions in a herd of dairy cattle. J. Vet. Diagn. Invest. 1: 205-209.
- Uggla, A., J. P. Dubey, G. Lundmark, and P. Olsen. 1989. Encephalitis and myositis in a boxer puppy due to a *Neospora*-like infection. Vet. Parasitol. 32: 55-260.



THE GORGAS SCHOLARSHIP FOUNDATION<sup>a</sup>  
AND  
THE ANNUAL ALABAMA TALENT SEARCH

Charles E. Feazel  
3929 Knollwood Trace  
Birmingham, AL 35243

ABSTRACT

The early history of the Gorgas Scholarship Foundation was recounted by Emmett B. Carmichael (1). He told how the idea of a foundation to aid science students was conceived in the minds of a few Alabama educators and industrialists and how the idea became a reality in 1948 with the help of the Alabama State Chamber of Commerce. The following is a summary of the activities of the Gorgas Foundation up to the present (2).

Emmett B. Carmichael, Professor of Biochemistry and Assistant Dean of the Medical College of Alabama, and J. L. Kassner, Professor of Chemistry at the University of Alabama, were the most interested of the academic supporters of the idea. Thomas W. Martin, Chairman of the Board of the Alabama Power Company, was the most active supporter in the industrial community.

They proposed an annual Alabama Science Talent Search to be conducted with the help of the National Science Talent Search carried out by Science Clubs of America for the Westinghouse Foundation, which awarded college scholarships for the study of science. The awards were based on the student's high school grades, a written aptitude examination, and an essay describing a science project.

To conduct the Alabama Science Talent Search, a committee of judges arranged, with Science Clubs of America, the receipt of all the Westinghouse entries from Alabama high schools each year. From this group, the judges were to choose finalists who would be invited to present the results of their science projects to a panel of judges. On the basis of the finalists' grades, accomplishments in the science projects, and individual interviews with the judges, winners of cash awards were to be selected. Colleges in the state were prepared to provide free tuition to some or all of the finalists. The cash awards were to be made with funds contributed by industrial donors.

Ten finalists were to be selected from entrants representing white schools and five from those representing black schools. Four cash awards were to be made in the former group and one in the latter.

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## Feazel

The first Alabama Talent Search was held in 1948: a total of fifteen finalists were selected, and five cash awards were made. The second Talent Search, in 1949, also resulted in five cash awards.

The Talent Search was evidently an immediate success with teachers and students. In 1948, 38 entries were submitted by students at 23 high schools. In 1949, 101 entries were submitted from 28 high schools. However, the Alabama State Chamber of Commerce, which had solicited money for support of the search, decided that it could no longer bear the responsibility involved. Without this backing, the program could not continue, and the Search was abandoned.

In 1952, the Talent Search was reactivated by Martin, who suggested the formation of the Gorgas Scholarship Foundation to administer the Annual Alabama Science Talent Search and the Gorgas Scholarships, to provide their financial support, and to receive contributions for these purposes.

The scholarships bear the name of William Crawford Gorgas, Surgeon-General of the United States Army. Dr. Gorgas, who was born in 1894 in Toulminville, near Mobile, was widely recognized as an authority on the public health aspects of controlling malaria and yellow fever. His work in the Canal Zone made possible the construction of the Panama Canal.

At the initial meeting of the Foundation, on October 9, 1952, 21 trustees were elected to represent colleges and industrial companies in the state. They serve three-year terms, after a first term of one year.

J. L. Kassner was elected Chairman at the 1952 meeting, and he continued in this office until 1957, when he was succeeded by Carmichael. Subsequent chairmen have been James B. Morgan, Chairman of the Board of Molton, Allen, and Williams (1973-1979); Robert D. Dortch, Vice-President, Birmingham-Southern College (1979-1981); Charles S. Alexander, Vice-President, Clark Substation Company (1981-1988); and, since 1988, Ruric E. Wheeler, Vice-President, Samford University.

At present, Glynn P. Wheeler (Southern Research Institute retired) is Secretary and Leven S. Hazlegrove (University of Alabama at Birmingham) is Chairman of Judges.

The general policies of the Foundation have remained the same as those initially adopted, although some of the operating procedures have changed over the years. Almost all of the colleges in the state have agreed to provide free tuition to some or all of the finalists. Any winner will forfeit the cash award if he or she attends college out of state. The scholarship must be used in the study of some science or engineering or a premedical, predental, or nursing curriculum. In 1968, the practice of holding separate contests for finalists from Negro schools was discontinued.

The number and amounts of cash awards have varied from time to time, depending on the financial reserves of the Foundation.

## Gorgas Scholarship Foundation

The Westinghouse contest annually receives about 3000 entries, from which their judges choose about 300 as members of a national "Honor Group." From this group, the Westinghouse judges then select about 40 "National Winners," who are invited to attend a meeting in Washington at which recipients of Westinghouse scholarships are chosen.

Any contestant who is named a National Winner or a member of the national Honors Group in the Westinghouse contest is automatically a finalist in the Gorgas competition. The Westinghouse judges have consistently named a few Alabama entrants almost every year to the Honors Group-Alabama students have done well in comparison to those from other states--but it was not until 1972 that an Alabama contestant, Bonnie Jean Luessen, from Grissom High School in Huntsville, was a National Winner. This title was awarded in 1980 to Gary Eugene McGahan, from Austin High School, in Decatur; in 1981 to William Shelton Chitwood, from Lawrence County High School; in 1982 to Gary Merle Griner, from Huntsville High School; in 1983 to Laura Leigh Huckabee, from Huntsville High School; and in 1986 to Yorita Saito, from Homewood High School. She was awarded third place in the Westinghouse competition.

The table lists the number of Alabama entries in the Westinghouse contest each year for 1948 through 1990. It also shows for each year the number of schools represented by these entries, as well as the number of entrants in the national Honors Group and National Winners. The table also shows the number of Gorgas finalists for each year.

### WESTINGHOUSE ENTRANTS AND HONORS; GORGAS FINALISTS

Year	Westinghouse Entrants	Schools	Honors Group	Gorgas Finalist
1948	38	23	1	15
1949	101	28	1	13
1953	36	12	0	14
1954	61	21	0	15
1955	80	25	3	15
1956	90	26	1	15
1957	104	27	2	16
1958	132	27	0	15
1959	107	36	2	15
1960	115	32	1	12
1961	121	37	5	13
1962	95	30	3	14
1963	114	26	1	17
1964	107	24	4	13
1965	101	35	3	14
1966	75	25	1	17
1967	82	27	1	16
1968	67	26	0	10
1969	65	27	2	11
1970	69	23	0	10

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1971	24	9	0	10
1972	30	19	6	9
1973	36	16	5	9
1974	33	16	5	10
1975	34	15	7	10
1976	23	12	4	9
1977	28	13	5	9
1978	13	7	1	7
1979	33	14	2	10
1980	40	7	4	12
1981	37	8	4	9
1982	39	14	5	9
1983	40	15	1	11
1984	27	13	3	10
1985	29	13	6	11
1986	30	14	4	12
1987	29	11	1	11
1988	61	17	2	11
1989	42	14	1	13
1990	33	7	4	9

The finalists in the Gorgas contest have come from 104 schools. The school with the most finalists over the period 1948-1990 has been Bradshaw High School, with a total of 48. Other schools that produced large numbers of finalists were Tuscaloosa (34), Fairfield (25), Parker (23), and Decatur (22).

Most of the finalists who have studied science have had or continue to have productive careers in science, medicine, or engineering. The Secretary of the Foundation has documented many of these careers with information obtained from the finalists by questionnaire. Many finalists have, of course, achieved success in fields other than the sciences.

## REFERENCES

1. Emmett B. Carmichael, The Alabama State Science Talent Search and Gorgas Scholarships, Chapter VIII in "A History of the Alabama Academy of Science," edited by C. H. Cantrell, P. C. Bailey, and S. B. Barker. Alabama Academy of Science, Auburn, Alabama, 1963.
2. Charles E. Feazel, History of the Gorgas Scholarship Foundation. Unpublished manuscript, 1986.



SYMPOSIUM ON THE STATUS OF ENDANGERED SPECIES IN ALABAMA<sup>1</sup>

Thomas S. Jandebeur  
Athens State College  
Department of Biology  
Athens, AL 35611

INTRODUCTION

In conjunction with the annual meeting of the Academy at Mobile College, on 9 March 1990 the Biology Section sponsored a Symposium on the Status of Endangered Species in Alabama, the fifth such symposium to be held in this state. Locations for the first three symposia, and publications stemming from them, are indicated by Modlin (1990). The fourth symposium was held on 24 March 1989 as part of the annual meeting of the Academy at Birmingham Southern College; the accomplishments of this symposium are reviewed by Modlin (1990). Four publications generated as a result of the fourth symposium and are included in the *Journal of the Alabama Academy of Science*, Vol. 61, No. 2, April 1990.

Organized by Dr. Dan Holliman, Birmingham Southern College, and myself, and moderated by Dr. Holliman, the most recent symposium focused on Alabama's coastal species and threats to their continued existence. Eight speakers contributed to the success of this symposium: Dr. Michel G. Lelong, University of South Alabama, presented information on endangered coastal plants; Dr. Robert L. Shipp, University of South Alabama, explored the vulnerability of several poorly known marine fishes; Mark Bailey, Alabama Natural Heritage Program, gave voice to the dusky gopher frog; Dr. James L. Dobie, Auburn University, discussed factors contributing to decline of the State Reptile, the Alabama rebbellied turtle; John Dindo, Dauphin Island Sea Lab, examined threats to coastal Alabama's avian nesting habitats; Earl Possardt, U.S. Fish and Wildlife Service, reviewed efforts to protect and conserve sea turtles in the southeastern continental U.S.; Keith Mullin, National Marine Fisheries Service, reported on the occurrence of cetaceans offshore of Alabama; and Dr. Nicholas R. Holler, Auburn University, discussed the status of endangered beach mouse populations. Each speaker is to be commended for his excellent presentation.

Five publications stemming from the Symposium are published in this issue of the *Journal*. I would like to thank the authors and co-authors of these papers for their effort and for their support of the *Journal*. Special thanks are due also to Dr. Holliman for his part in reviewing the manuscripts, and to Dr. William H. Mason, Editor of the *Journal*, for providing the avenue for dissemination of information developed in the two most recent symposia.

LITERATURE CITED

- Modlin, Richard F. 1990. "Symposium on the Status of Endangered Species: Introduction." *Jour. Al. Acad. Sci.* 61(2):62-63.



ENDANGERED MARINE FISHES OF ALABAMA; ARE THERE ANY?<sup>1</sup>

Robert L. Shipp  
Department of Biological Sciences  
University of South Alabama  
Mobile, AL 36688

INTRODUCTION

Marine habitats tend to engender less small scale isolation than do terrestrial or freshwater habitats. Thus species ranges for marine species normally are far greater than those of their counterparts in other ecological settings. Not surprisingly, practically every species of North American freshwater fish has a limited distribution across the North American continent, most restricted to single drainage systems (Lee et al., 1980). Conversely, the great majority of nearshore marine fishes of the Gulf of Mexico have extended distribution throughout that entire sea, most with ranges extending into the Atlantic coast of the U.S. (Hoese and Moore, 1977; Robins et al., 1986; Shipp, 1986). Therefore, the potential of threatened or endangered status for marine fishes, caused by regional habitat transformation or degradation, is much reduced.

Nevertheless, heated controversy regarding intense overfishing on several marine species has led the public to perceive such species as the red drum (*Sciaenops ocellatus*) and the red snapper (*Lutjanus campechanus*) as threatened or endangered. While stocks of these species may be depleted relative to commercial or recreational scales, no studies to date have indicated population levels which would even remotely indicate serious threats to existence of the species. Combined with our knowledge of the noncommercial species, there are currently no species of marine fishes off the north central Gulf Coast which appear to be in any danger of approaching critically low population levels. However, there may be one or two anadromous forms whose status is unclear. In addition, recent surveys have revealed some unique marine habitats off Alabama and the Florida panhandle which deserve further study as to their geographic extent and support of dependent ichthyofauna.

ANADROMOUS SPECIES

The Gulf of Mexico sturgeon, *Acipenser oxyrhynchus desotoi* has been extensively discussed as per its possible threatened status (Boschung, 1976; Deacon et al., 1979; Gilbert, 1978; Smith, 1985; Wood, 1987; Wooley and Crateau, 1985). These published reports, as well as numerous unpublished species status papers, focus on the taxonomic status of the

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<sup>1</sup>This article was presented as an invited paper at a Symposium on the Status of Endangered Species in Alabama on 9 March 1990 at the annual meeting of the Alabama Academy of Science held at Mobile College, Mobile Alabama.

subspecies, distribution, declining stocks, and habitat degradation. Since this appears the only anadromous species in the Gulf of Mexico for which there exists expressions of concern in the scientific literature, I will provide the following synopsis of its status.

Vladykov (1955) designated the Gulf of Mexico sturgeon as subspecifically distinct from the Atlantic populations, and conferred the trinomial *Acipenser oxyrhynchus desotoi*, with the holotype taken from the mouth of the Singing River in Mississippi Sound, south of Gautier, Mississippi. The subspecies occurs from the Mississippi to the Suwanee River, and in marine waters of the northeast Gulf of Mexico.

The only other sturgeons likely to be found with *A. o. desotoi* are the two species of *Scaphirhynchus*. *Acipenser* possesses spiracles, has a subconical snout, a tail which is not mailed, and lanceolate gill rakers; *Scaphirhynchus* is lacking spiracles, has a shovel-shaped snout, a completely mailed tail, and fan-shaped gill rakers (Vladykov and Greeley, 1963).

Gulf of Mexico sturgeons grow to at least 2.25 m, and an age of at least 21 years. Barkuloo (1988) indicated that these sturgeons spend the first three years in fresh and estuarine habitats, then begin the migratory pattern of the adults. These larger fish feed almost entirely on marine and estuarine organisms, living off stored fat while in fresh waters. Huff (1975) reported males mature at age 7 to 10, and females at age 8 to 12, in the Suwanee River.

Gulf of Mexico sturgeons have been fished commercially for about 100 years, with peak production (351,000 pounds) in 1902. The fishery was almost exclusively in the Apalachicola River, with sporadic catches from the Mobile system in Alabama. The fishery declined to less than 1,000 pounds annually in the 1980s, and was essentially nonexistent after 1985 (Miranda and Jackson, 1985; Barkuloo, 1988).

Records from numerous unpublished accounts indicate current populations in Lake Pontchartrain, Pearl River, Pascagoula River, Mobile Bay System, Escambia River, Yellow River, Choctawhatchee River, Apalachicola River, and the Suwanee River. Populations from this latter location are probably the healthiest of the Gulf, as evidenced from 1988 tagging studies (Barkuloo, 1988).

As of 1985, the U.S. Fish and Wildlife Service assigned the Gulf of Mexico sturgeon to Category 2 (Federal Register, September 15, 1985). This indicates the taxon should probably be listed as endangered or threatened, but for which data on biological vulnerability were not conclusive. A complete manuscript summary of the current status of the Gulf of Mexico sturgeon is available from Barkuloo (1988).

The Alabama shad *Alosa alabamae* has not been represented in collections from appropriate habitats in Alabama during the late 1970's and 1980's (Scott Mettee, pers. comm.). Populations of this species continue to occur from the Florida panhandle, but because of its drasti-

## Endangered marine fishes of Alabama

cally reduced numbers in some areas, possibly due to lock construction and siltation (Lee et al., 1980), special attention needs to be accorded this fish during the upcoming decade.

### EXCLUSIVELY MARINE SPECIES

Of the exclusively marine forms, there are several poorly known cryptic species occurring in specialized habitats along the midshelf region of the Gulf of Mexico whose status is unclear. Two of these are chaenopsid blennies, *Chaenopsis roseola*, the freckled pikeblenny, and *Emblemaria piratula*, the pirate blenny (Williams and Shipp, 1980; Hastings and Shipp, 1981). These species are restricted to rubble/shell hash bottoms of the northeastern Gulf of Mexico at depths of from approximately thirty to sixty meters. This habitat is extremely difficult to collect, especially for these diminutive forms. Capetown dredge with fine mesh liner has proven effective but very labor intensive. For these reasons, the abundance of these and numerous associated forms is unclear. However, these habitats appear to be of very limited coverage, and are located in areas of active hydrocarbon exploration.

The freckled pikeblenny may have the greater geographical range of the two species, but the status of its close congeners is currently unclear. Records of this or closely related forms from Yucatan or the Atlantic Coast of the United States remain ambiguous because of unresolved taxonomic questions. The pirate blenny appears to have a more restricted range (northeastern Gulf of Mexico), with little confusion as to its taxonomic status. Several other poorly known cryptic forms (e.g. *Gobulus myersi*, *Palatogobius paradoxus*, and *Gillelus* sp.) co-occur on this distinctive substrate.

While none of these exclusively marine species is herein considered threatened or endangered, their possible limited range and apparent specialized habitat render them most vulnerable in the event of major environmental modification in the Gulf of Mexico.

### LITERATURE CITED

- Barkuloo, J. M. 1988. Report on the conservation status of the Gulf of Mexico Sturgeon. Unpubl. U.S. Fish and Wildl. Service, Panama City, FL.
- Boschung, H. (ed.) 1976. Endangered and threatened plants and animals of Alabama. Bull. AL. Mus. Nat. Hist. No. 2. 57 pp.
- Deacon, E., G. C. Kobetich, J. E. Williams, S. Contreras. 1979. Fishes of North America endangered, threatened, or of special concern. Fisheries 4(2):29-44.
- Gilbert, c. R. (ed.) 1978. Atlantic sturgeon. In: Rare and endangered biota of Florida, Vol. 4:5-8, Fishes, Univ. Presses of Florida.



## Shipp

- Hastings, P. A. and R. L. Shipp. 1981. A new species of pikeblenny (Pisces: Chaenopaidae: *Chaenopsis*) from the western Atlantic. Proc. Biol. Soc. Wash. 93(4):875-886.
- Hoese, H. D. and R. H. Moore. 1977. Fishes of the Gulf of Mexico, Texas, Louisiana, and adjacent waters. TAMU Press. 327 pp.
- Huff, J. A. 1975. Life history of the Gulf of Mexico Sturgeon, *Acipenser oxyrhynchus desotoi* in Suwannee River, Florida. Mar. Res. Publ. 16. 32 pp.
- Lee, D. S., C. R. Gilbert, C. H. Hocutt, R. E. Jenkins, D. E. McAllister, 2nd, J. R. Stauffer, Jr. 1980. Atlas of North American freshwater fishes. N. Carolina Biol. Survey Publ. 1980-12. 854 pp.
- Miranda, L. E. and D. C. Jackson. 1987. A status survey of Atlantic sturgeon in the Pascagoula and Pear River Systems of Mississippi. Unpubl. Miss. Dept. of Wildl. and Fish. 27 pp.
- Robins, C. R., G. C. Ray, and J. Douglass. 1986. A field guide to Atlantic Coast fishes of North America. Houghton Mifflin Co. 352 pp.
- Shipp, R. L. 1986. Dr. Bob Shipp's guide to fishes of the Gulf of Mexico. KME Seabooks, Mobile. 256 pp.
- Smith, T.I.J. 1985. The fishery, biology, and management of the Atlantic sturgeon, *Acipenser oxyrhynchus*, in North America. In: North American Sturgeons: biology and aquaculture potential, F. O. Binkowski and S. I. Doroshov (eds.) D. W. Funk, Netherlands. 163 pp.
- Vladykov, V. D. 1955. A comparison of Atlantic sea sturgeon with a new subspecies from the Gulf of Mexico (*Acipenser oxyrhynchus desotoi*). J. Fish. Res. Bd. Can. 12(5): 754-761.
- Vladykov, V. D. and J. R. Greeley. 1963. Order Acipenseroides. In: Fishes of the western North Atlantic. Memoir. Sears Foundation for Marine Research, 1(3):24-58.
- Williams, J. T. and R. L. Shipp. 1980. Observations on fishes previously unrecorded or rarely encountered in the northeastern Gulf of Mexico. North. Gulf. Sci. (4(1):17-27.
- Wood, D. A. 1987. Official list of endangered and potentially endangered fauna and flora in Florida. Fla. Game and Freshwater Fish Com. 19 pp.
- Wooley, C. M. and E. J. Crateau. 1985. Movement, microhabitat, exploitation and management of Gulf of Mexico sturgeon, Apalachicola River, Florida. N. Amer. J. Fish. Manage: 590-605.



STATUS OF ENDANGERED BEACH MOUSE POPULATIONS IN ALABAMA<sup>1</sup>

Nicholas R. Holler

*U. S. Fish and Wildlife Service*

*Alabama Cooperative Fish and Wildlife Research Unit<sup>2</sup>*

*Department of Zoology and Wildlife Science*

*Auburn University, AL 36849-5414 (NRH)*

and

Elizabeth H. Rave

*Alabama Cooperative Fish and Wildlife Research Unit*

*Department of Zoology and Wildlife Science*

*Auburn University, AL 36849-5414*

*Present Address of EHR:*

*Department of Biology, University of North Dakota*

*Grand Forks, ND 58202*

ABSTRACT

Two endangered subspecies of beach mice (*Peromyscus polionotus*) occur on the coastal dunes of Alabama. The Perdido Key beach mouse (*P. p. trissyllepsis*) formerly occurred in more or less continuous populations along the coast of Perdido Key in Alabama and Florida. In April 1986 it existed only as one small population of less than 30 individuals in Alabama. The population had increased greatly by April 1987 and numbered more than 100 by November 1987; it appears to have stabilized at that level. A second population has been established at Gulf Islands National Seashore in Florida through translocation. That population has occupied 11 km (approximately 160 ha) of dune habitat and probably has exceeded 100 individuals since June 1989. The Alabama beach mouse (*P. p. ammobates*) formerly occurred on Ono Island and along the coast from Perdido Pass to Fort Morgan. It was extirpated from Ono Island by 1982. In 1987, we found remaining populations at and between Bon Secour National Wildlife Refuge (Perdue Unit) and Fort Morgan. Alabama beach mice may be extirpated from Gulf State Park, where domestic cats (*Felis silvestris*) are common and house mice (*Mus musculus*) occur. Trapping at Bon Secour NWR and Fort Morgan from 1987 through 1990 showed that those areas remain fully occupied. Tropical storms pose the most serious threat to remaining

<sup>1</sup>This article was presented as an invited paper at a Symposium on the Status of Endangered Species in Alabama on 9 March 1990 at the annual meeting of the Alabama Academy of Science held at Mobile College, Mobile Alabama.

<sup>2</sup>Cooperators: U.S. Fish and Wildlife Service, Game and Fish Division of the Alabama Department of Conservation and Natural Resources, Wildlife Management Institute, Auburn University (Alabama Agricultural Experiment Station--Contribution #15-902740P, Department of Fisheries and Allied Aquacultures, Department of Zoology and Wildlife Science).

NWR and Fort Morgan from 1987 through 1990 showed that those areas remain fully occupied. Tropical storms pose the most serious threat to remaining populations.

## INTRODUCTION

The oldfield mouse (*Peromyscus polionotus*) ranges over much of the southeastern United States (Hall, 1981) where it commonly occurs in open fields with sandy soils. The term "beach mouse" (Bowen, 1968) is collectively applied to 8 subspecies of *P. polionotus* that are restricted to coastal dune systems along the Gulf Coast of Alabama and Florida and the Atlantic coast of Florida. The beach forms tend to be lighter in coloration than inland forms of *P. polionotus*, show variable amounts of white on the face, and have a reduced or no tail stripe.

One beach mouse subspecies, the Alabama beach mouse, is endemic to Alabama, and another, the Perdido Key beach mouse, occurs in Alabama and Florida. The other 6 subspecies of beach mice, one of which is believed to be extinct, are endemic to Florida (Bowen, 1968). Beach mouse populations have been reduced severely in recent years by human alterations of coastal dune ecosystems. Four of the beach mouse subspecies, including both Alabama forms, are listed as endangered and one is listed as threatened by the U.S. Fish and Wildlife Service; one other subspecies is listed as endangered by Florida but is not yet on the federal list (Wood and Holler, 1990). Only the Santa Rosa beach mouse (*P. p. leucocephalus*) is not currently in danger of extinction.

Beach mice in Alabama occupy primary and secondary beach dunes vegetated primarily with sea oats (*Uniola paniculata*), beach grass (*Panicum amarum*), and bluestem (*Andropogon maritimus*). They also occur in the older scrub dunes found adjacent to and immediately inland to the optimal habitat. Common vegetation in these dunes includes scrubby oaks (*Quercus* spp.), pines (*Pinus* spp.), saw palmetto (*Serenoa repens*), and rosemary (*Ceratiola ericoides*; Hill, 1989). *P. polionotus* is nocturnal (Wolfe and Esher, 1978) and inhabits burrows (Hayne, 1936) which, for beach forms, usually are located on the sides of dunes (Ehrhart, 1978a, 1978b).

## REASONS FOR ENDANGERMENT

Five factors have contributed to the endangerment of beach mouse populations. *Habitat loss*, as a result of real estate development in the beach dune habitat, is the most important factor which has resulted in the endangered status of the beach subspecies (Bowen, 1968; Arnett, 1984). Past construction often has occurred directly on the crest of the dunes, resulting in total habitat loss. Some areas of private ownership still are subject to development. Additionally, major habitat loss can occur as a result of tropical storms or hurricanes. Hurricane Elena (in 1985) destroyed large areas of beach mouse habitat in Alabama (U.S. Fish and Wildlife Service, 1986). Habitat lost or damaged during storms, however, may be restored such that it may once again support mouse populations (Holler et al., 1989).

## Endangered beach mouse populations

*Predation*, especially by domestic cats, also is thought to cause loss of beach mouse populations (Bowen, 1968). Holliman (1983) believed this may have been a major factor in the extirpation of Alabama beach mice from Ono Island. Natural predators, such as the red fox (*Vulpes vulpes*) and the eastern coachwhip snake (*Masticophis flagellum flagellum*), may be a cause for concern following storm damage to habitat, but probably do not threaten mouse populations in good habitat.

*Competition* with house mice (an introduced species) may contribute to the loss of local beach mouse populations, especially near developed areas (Briese and Smith, 1973; Humphrey and Barbour, 1981). The importance of this factor, however, may vary with food supply and relative densities of the 2 species (Caldwell, 1964; Caldwell and Gentry, 1965; Gentry 1966; Briese and Smith 1973).

*Loss of genetic diversity* may be an important factor in the remaining small, isolated populations. Genetic exchange between many populations is no longer possible, and some populations have been through several recorded genetic bottlenecks (Humphrey and Barbour, 1981; Holler et al., 1989); information on resultant gene frequencies is lacking. Inbreeding and associated loss of rare alleles may result in reduced ability of the mice to adapt to environmental changes.

Finally, *disease* may be an important factor influencing survival of the remaining populations. Although loss of populations as a result of disease has not been documented, the restricted nature of the remaining populations makes them susceptible to this factor. Potential introduction of disease must be considered in exchanges of individuals between populations.

## STATUS

### *Perdido Key beach mouse*

Historically, this form lived in the coastal dunes along the length of Perdido Key in Alabama and Florida. The subspecies was found at only 2 locations in 1979 (Humphrey and Barbour, 1981): 51 individuals were trapped at Gulf Islands National Seashore at the eastern end of Perdido Key in Florida, and 26 at Gulf State Park in Alabama on the western tip of Perdido Key. Following Hurricane Frederic in 1979, only 1 small population remained at Gulf State Park, where 13 individuals were captured in 1982 (Meyers, unpublished; cited in U.S. Fish and Wildlife Service 1987). Neither Humphrey and Barbour nor Meyers were able to locate mice in the central portion of Perdido Key. The subspecies was listed as endangered pursuant to the Endangered Species Act of 1973 on June 6, 1985 (50 FR 23872).

In 1986, the Florida Game and Fresh Water Fish Commission, in cooperation with the Alabama Cooperative Fish and Wildlife Research Unit, National Park Service, Alabama Division of Game and Fish, and Alabama Division of Parks, initiated a program to reestablish the Perdido Key beach mouse on the national seashore. Seventeen pairs of mice were



translocated from Gulf State Park in Alabama to the seashore in Florida between fall 1986 and spring 1989 (Fig. 1). Subsequent trapping along 6.2 km of the seashore and observation of tracks throughout the dune habitat indicated that the population was well-established (Holler et al., 1989) and probably had exceeded 100 individuals by June 1989 (Holler, unpublished data).

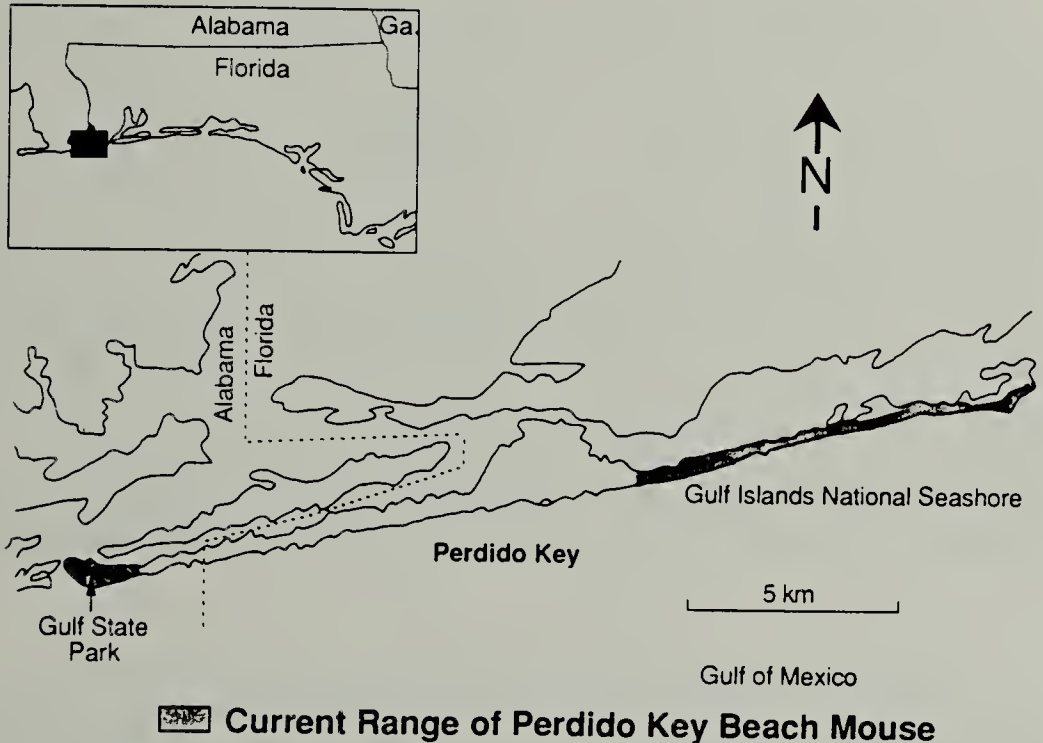


Figure 1. Range of the Perdido Key beach mouse in Alabama and Florida, 1990.

The reestablished population on Gulf Islands National Seashore now appears stable in approximately 11 km of habitat. This population is still susceptible to loss by storm damage. Although several lines of dunes are present in some areas, there are no high scrub dunes on the landward side of the island. The seashore is presently included in a major beach renourishment project which has resulted in considerable widening of the beach between the dunes and the ocean. The effects of this project on the beach mice are not yet known. If it results in an increase in the dune habitat it could be beneficial. Major physical and vegetative changes in the existing dunes, however, could be detrimental. Two house mice were captured on the seashore in 1990 (Holler, unpublished data); however, there is no evidence of a reproducing population of these potential competitors.



## Endangered beach mouse populations

The donor population at Gulf State Park, Alabama was probably less than 30 individuals in April 1986, when the translocation effort began (Holler et al., 1989). A substantial increase in the population had occurred by April 1987, and by November 1987 the population exceeded 100 individuals (Holler et al., 1989) and has remained at that level through summer 1990 (Holler, unpublished data).

The population at Gulf State Park in Alabama is extremely susceptible to storm damage. The habitat consists of only 1 line of well-formed dunes which could be destroyed during a severe storm with overwash. Some new dune habitat is forming north of Highway 182, but that land is in private ownership and subject to development. Because the block of dune habitat is small (approximately 1.5 km long), this population of mice will never be large. Thus, loss of genetic diversity within the population and potential for stochastic loss of the population are major concerns. Also, the occupied habitat is bordered on the east by developed beach, which may facilitate invasion of the habitat by house mice and domestic cats. The status of the subspecies in Alabama has been improved through the reestablishment of the Florida population. The existence of 2 separate populations provides some protection against total loss due to storms. Exchanges of individuals between populations are being made to reduce the loss of genetic diversity and to maintain genetic compatibility between the 2 populations. Public purchase of the land north of Highway 182, and management of that area to speed development of dune habitat would improve the status of this population. Conversely, development of that land, with resultant increased human use of the beach habitat, could be detrimental.

### *Alabama beach mouse.*

*Distribution.* Historically, this subspecies occurred on Ono Island and along the Fort Morgan Peninsula from Perdido Pass to Fort Morgan. Between 1921 and 1983, commercial and residential development and recreational activities destroyed approximately 62% of the beach mouse habitat in Alabama (Holliman, 1983). The subspecies had been extirpated from Ono Island and areas east of Romar Beach.

We trapped all undeveloped habitat along Fort Morgan Peninsula at least once during 1987 and 1988. We also trapped some non-critical habitat (> 152 m inland from the mean high tide line) to determine inland distribution of beach mice. Traps were baited with either peanut butter and oats or with apple. Depending on the presence of dune types at a particular site, traps were placed along frontal, secondary, and scrub dunes. Trapping periods extended over 2 to 5 nights.

Critical habitat sites A, B, D, E, F, G, and I (Fig. 2) had beach mouse populations (Table 1). No beach mice were captured at Gulf State Park (site K); however, 8 house mice were captured at that site. Domestic cats also were abundant at Gulf State Park. Since neither Holliman (1983) nor we captured beach mice at this site, the subspecies may have been extirpated. Predation by domestic cats and competition with house mice are possible causative factors in extirpation of the beach mice. Non-critical habitat sites C and H also supported beach mice; however, mice

were not captured at the inland site J. We captured beach mice in scrub dunes (sites C, G, and H), some of which were located several hundred meters from the frontal dunes. Because hurricanes may cause temporary flooding or destroy large areas of beach dune habitat, scrub dunes may be important refuges for mice.

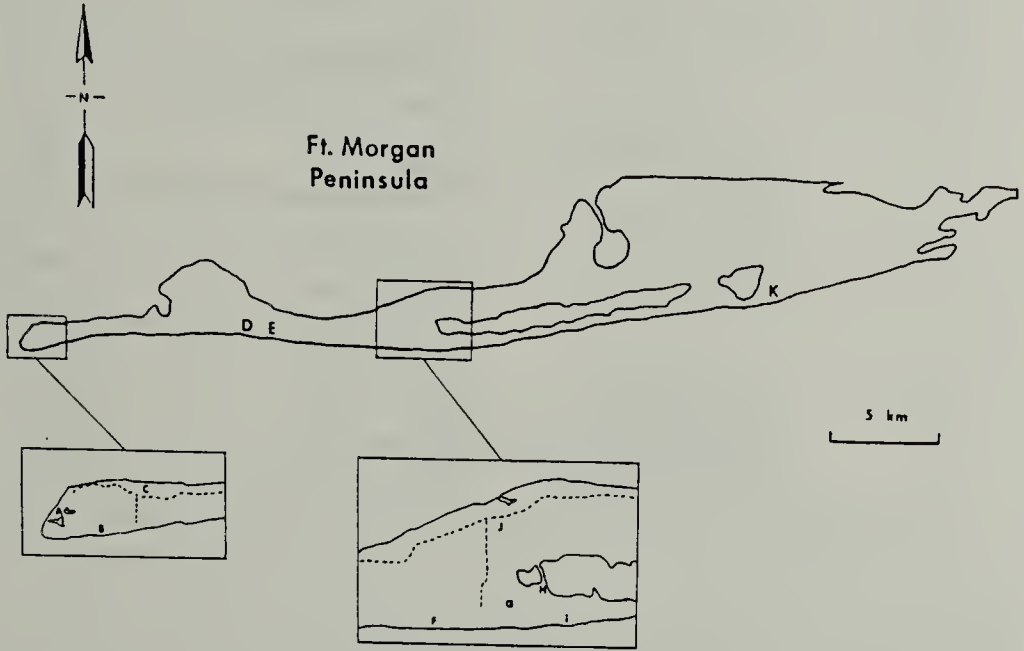


Figure 2. Location of sites trapped during distribution survey of Alabama beach mice along Fort Morgan Peninsula, January 1987 to August 1988.

We captured between 0.20 and 7.20 mice per 100 trap nights at occupied sites (Table 1). Population numbers and probability of capture of beach mice can fluctuate greatly during the year. Therefore, low trap response during short-term trapping is difficult to assess. The rate of capture can be the result of either density or trap response, which may be influenced by bait, food availability, habitat, season, weather, sex, and reproductive condition (Kaufman et al., 1974). Consequently, data from areas trapped once along Fort Morgan Peninsula can document only the presence of mice, not relative abundance. The Alabama beach mouse now occurs on Bon Secour NWR (Perdue Unit) and west along the Fort Morgan Peninsula in areas of undeveloped beach dune habitat (Fig. 3). Major protected populations are on the refuge at the Perdue Unit and at the Fort Morgan Unit, a state historical site leased and managed by the U.S. Fish and Wildlife Service.

## Endangered beach mouse populations

Table 1. Captures of Alabama Beach Mice per 100 Trap Nights at Trapped Sites Along Ft. Morgan Peninsula, Alabama, January 1987 - August 1988.

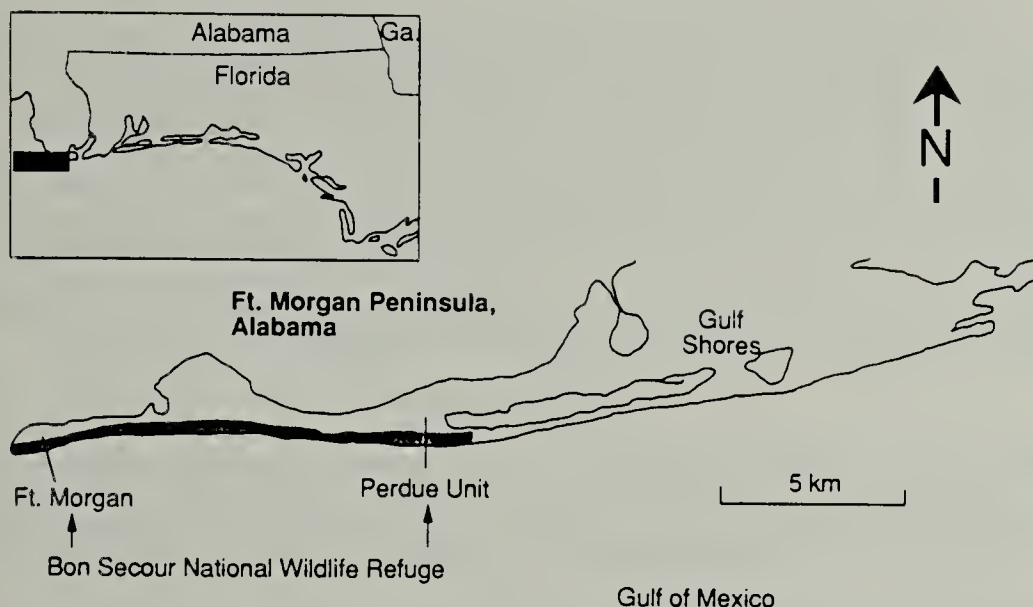
SITE	LOCATION	DATE	CAPTURES PER 100 TRAP NIGHTS
A	Fort Morgan	Fall 1987	0.67
B	Fort Morgan	Winter 1987	0.20
		Spring 1987	4.00
		Summer 1987	7.20
C	Fort Morgan	Spring 1988	2.50
D	Surfside Shores	Summer 1988	3.00
E	Gulf Shores	Winter 1987	1.79
	Plantation		
F	Perdue Unit	Fall 1987	3.75
G	Perdue Unit	Winter 1987	2.55
		Spring 1987	4.00
		Summer 1987	6.50
H	Perdue Unit	Spring 1988	0.25
I	Perdue Unit	Winter 1987	0.25
J	Perdue Unit	Spring 1987	0.00
K	Gulf State Park	Fall 1987	0.00

### *Perdue Unit and Fort Morgan Unit Populations.*

We have been studying the populations at the Perdue and Fort Morgan Units of Bon Secour NWR since the winter of 1987. Populations at both sites were quite low when we began seasonal trapping in January 1987. This may have been due to the habitat destruction and associated loss of mice resulting from Hurricane Elena. Habitat at Fort Morgan had been reduced to only a few scattered primary and secondary dunes separated by several hundred meters from the scrub dunes. Although loss of habitat was not as great at the Perdue Unit, there were large gaps (blowouts) in the dune system at that site as well. The presence of scrub dunes at both sites may have offered protection against total loss of the populations. Beach mice utilize these dunes at both sites.

Populations at the Perdue and Fort Morgan Units showed a general increase during 1987 and, except for seasonal fluctuations, have stabilized at high levels. All habitat at both areas is occupied by beach mice. The dune habitat has recovered from the effects of Hurricane Elena, due in part to restoration efforts by the staff of Bon Secour NWR. Lines of hay bales were used to initiate the development of new dunes and fertilizer was applied to the existing dune system.

Because of the well-developed scrub dune system, the Perdue and Fort Morgan Unit populations probably are not at as great a risk of total loss during storms as is the Perdido Key beach mouse population at Gulf State



### ■ Current Range of Alabama Beach Mouse

Figure 3. Range of the Alabama beach mouse, 1990.

Park. Habitat at both sites also is more extensive, permitting maintenance of larger populations than at Perdido key, Alabama, and reducing the potential for loss of genetic diversity or stochastic loss of entire populations. Nevertheless, habitat loss resulting from storms is probably the greatest threat to the subspecies. Additionally, domestic cats or their sign frequently are seen at both sites, especially at Fort Morgan. House mice also are captured occasionally in the dunes at Fort Morgan. Privately owned undeveloped beach habitat still exists and is subject to development. One such area is adjacent to the Perdido Unit on Bon Secour NWR. Public purchase and protection of these lands would improve the status of the subspecies.

### CONCLUSION

The Perdido Key beach mouse is one of Alabama's most endangered vertebrates. It is restricted, in Alabama, to only 1.5 km of beach habitat at the western end of Perdido Key. Although this habitat is in public ownership and protected, its small size and the lack of depth in the dune system result in high susceptibility to storm damage. The population of mice at this location can never be large. Thus, loss of genetic diversity remains a major concern, and the potential for stochastic loss of the population during a normal population low exists. Some additional habitat exists north of the beach, but it is in private ownership. Public purchase of this property is recommended. Status of the subspecies has been improved by the reestablishment of a population in Florida. This could serve as a source of animals should loss of the Alabama population occur.



## Endangered beach mouse populations

The Alabama beach mouse has now been restricted to areas on Fort Morgan Peninsula including and west of the Perdue Unit, Bon Secour NWR. Although populations at both the Perdue and Fort Morgan Units of the refuge appear stable and somewhat protected from storm loss by well-developed scrub dune systems, they are still at risk. Domestic cats occur at both sites and house mice occasionally are trapped at Fort Morgan. Remaining habitat for this subspecies is more extensive and potential for genetic or stochastic loss is not as high as that for the Perdido Key beach mouse in Alabama. Public purchase and protection of remaining undeveloped land in private ownership is the most important recovery action which could be undertaken for this subspecies.

### LITERATURE CITED

- Arnett, G. R. 1984. Endangered and threatened wildlife and plants; proposed endangered status and critical habitat for the Alabama beach mouse, Perdido Key beach mouse, and Choctawhatchee beach mouse. U.S. Fish and Wildlife Service. Fed. Reg. 49:23794-23804.
- Bowen, W. W. 1968. Variation and evolution of Gulf Coast populations of beach mice, *Peromyscus polionotus*. Bull. Fla. St. Mus., Biol. Sci. 12:1-91.
- Briese, L. A. and M. H. Smith. 1973. Competition between *Mus musculus* and *Peromyscus polionotus*. J. Mammal. 54:968-969.
- Caldwell, L. D. 1964. An investigation of competition in natural populations of mice. J. Mammal. 45:12-30.
- \_\_\_\_\_ and J. B. Gentry. 1965. Interactions of *Peromyscus* and *Mus* in a one-acre field enclosure. Ecology. 46:189-192.
- Ehrhart, L. M. 1978a. Choctawhatchee beach mouse. Pp. 18-19 in J. N. Layne (ed.), Rare and endangered biota of Florida. Vol. 1. Mammals. Univ. Presses of Florida, Gainesville.
- \_\_\_\_\_. 1978b. Pallid beach mouse. Pp. 8-10 in J. N. Layne (ed.), Rare and endangered biota of Florida. Vol. 1. Mammals. Univ. Presses of Florida, Gainesville.
- Gentry, J. B. 1966. Invasion of a one-year abandoned field by *Peromyscus polionotus* and *Mus musculus*. J. Mammal. 47:431-439.
- Hall, E. R. 1981. The mammals of North America. John Wiley and Sons, New York. 1181 + 90 pp.
- Hayne, D. W. 1936. Burrowing habits of *Peromyscus polionotus*. J. Mammal. 17:420-421.
- Hill, E. A. 1989. Population dynamics, habitat, and distribution of the Alabama beach mouse. M.S. Thesis. Auburn Univ. 53 pp.

- Holler, N. R., D. W. Mason, R. M. Dawson, T. Simons, and M. C. Wooten. 1989. Reestablishment of the Perdido Key beach mouse (*Peromyscus polionotus trissyllepsis*) on Gulf Islands National Seashore. *Conserv. Biol.* 3:397-404.
- Holliman, D. C. 1983. Status and habitat of Alabama Gulf Coast beach mice *Peromyscus polionotus ammobates* and *P. p. trissyllepsis*. *Northeast Gulf Sci.* 6:121-129.
- Humphrey, S. R. and D. B. Barbour. 1981. Status and habitat of three subspecies of *Peromyscus polionotus* in Florida. *J. Mammal.* 62:840-844.
- Kaufman, D. W., S. E. Fuller, M. J. O'Farrell, and M. H. Smith. 1974. Trap response in *Peromyscus polionotus*. *Acta Theriol.* 19-376-378.
- U.S. Fish and Wildlife Service. 1986. Hurricanes damage southeastern beach mouse habitat. *Endangered Species Tech. Bull.* 11:7-8.
- \_\_\_\_\_. 1987. Recovery plan for the Alabama beach mouse (*Peromyscus polionotus ammobates*), Perdido Key beach mouse (*P. p. trissyllepsis*), and Choctawhatchee beach mouse (*P. p. allophrys*). U.S. Fish and Wildlife Service, Atlanta, Georgia. 45 pp.
- Wolfe, J. L. and R. J. Esher. 1978. The behavior of a burrowing mouse (*Peromyscus polionotus*) in a residential maze. *J. Mississippi Acad. Sci.* 23:100-109.
- Wood, D. A. and N. R. Holler. 1990. Of men and mice. *Florida Wildl.* 44(4):37-39.

THE DUSKY GOPHER FROG IN ALABAMA<sup>1</sup>

Mark A. Bailey  
Alabama Natural Heritage Program  
Department of Conservation and Natural Resources  
State Lands Division  
Montgomery, AL 36130

ABSTRACT

The dusky gopher frog (*Ranidae: Rana capito sevosa*) is one of Alabama's rarest and most poorly known amphibians. Only five extant breeding ponds (representing perhaps three separate populations) are known in the state. Rangewide (LA, MS, GA, FL and AL), fewer than 10 extant populations are known. A survey, funded by the U.S. Forest Service, is being conducted by the Alabama Natural Heritage Program on the Conecuh National Forest to determine periods of breeding activity, distribution, and habitat. An Escambia County breeding pond was used by at least 269 adults during the 1986 winter breeding season. In Alabama, documented declines in gopher frog populations have resulted from road construction through a breeding site and introduction of fish to a breeding pond. Additional threats include conversion of natural sandhill habitat to commercial pine stands and siltation of breeding ponds. Needed to ensure the long-term survival of the dusky gopher frog in Alabama are: 1) protection of breeding sites and enhancement of gopher tortoise habitat on adjacent uplands, 2) surveys for new populations, and 3) further research into home range, larval ecology, and population genetics.

INTRODUCTION

The ranid frog genus *Rana* is essentially cosmopolitan in distribution, but fewer than 20 of the approximately 400 species occur in the United States. Eight species are known from Alabama. Although the wood frog (*R. sylvatica*) and the river frog (*R. heckscheri*) are rare in Alabama, both are peripheral species and common elsewhere, with only small portions of their ranges extending into the state. Six ranids range across a substantial portion of Alabama: the bullfrog (*R. catesbeiana*), green frog (*R. clamitans* ssp.), southern leopard frog (*R. sphenoccephala*), pickerel frog (*R. palustris*), pig frog (*R. grylio*), and dusky gopher frog (*R. capito sevosa*). Of these, the dusky gopher frog is by far the rarest and most poorly known.

Until recently, most authors have considered the gopher frogs and crawfish frogs as conspecific members of the crawfish frog (*Rana areolata* ssp.) complex. However, a variety of published and unpublished data

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<sup>1</sup>This article was presented as an invited paper at a Symposium on the Status of Endangered Species in Alabama on 9 March 1990 at the annual meeting of the Alabama Academy of Science held at Mobile College, Mobile Alabama.

indicate the gopher frogs to be specifically distinct from the crawfish frogs, and the most recent literature treats them as such (see Collins, et al. 1990).<sup>2</sup> *Rana capito* ssp. historically ranged from Louisiana to North Carolina, and is almost wholly restricted to the Gulf/Atlantic Coastal Plain. Three subspecies are currently recognized: *R. capito capito*, the Carolina gopher frog; *R. c. aesopus*, the Florida gopher frog; and *R. c. sevosia*, the dusky gopher frog. Precise ranges and zones of intergradation are poorly known (Altig and Lohoefer 1983).

The dusky gopher frog, according to current accounts, occurs from southeastern Louisiana (where it is likely extirpated) to extreme western Georgia, with most of its range in southern Mississippi and Alabama and in the western portion of the Florida Panhandle. Gopher frogs are normally found in sympatry with the gopher tortoise (*Gopherus polyphemus*) (Wright 1932, Carr, 1940, Means 1986). Gopher frogs are often found in and near tortoise burrows, where presumably they avoid adverse environmental conditions and find prey.

The only known occurrence of the dusky gopher frog outside the present range of the gopher tortoise and above the Fall Line is an apparently isolated (and quite possibly extirpated) population in the Coosa River watershed in Shelby County, Alabama, nearly two hundred miles north of the nearest known population. Several other typically Coastal Plain vertebrates have disjunct populations in this region, including the pine woods treefrog (*Hyla femoralis*), the southern hognose snake (*Heterodon simus*), and the eastern coral snake (*Micrurus fulvius*) (Redmond 1975). Despite intensive searches for additional specimens from the Shelby County area since the discovery of one specimen reported by Mount in 1964, a second specimen was not found there until 1983 (Guthrie 1983). Further searching has revealed no more specimens. The difficulty encountered in finding specimens from this known area of occurrence demonstrates the problems involved in locating new populations and thus determining the precise distribution and status of this secretive animal.

The dusky gopher frog historically has been recorded from ten other localities in Alabama: three in Escambia County, three in Covington County, and one each in Barbour, Baldwin, Coffee, and Mobile counties (Mount 1980; pers. obs.). The 1957 Coffee County record, represented by an uncatalogued lot of tadpoles at the Florida Museum of Natural History, has not been previously published. Only eight breeding sites have been located in Alabama, and of these, only five are known to support perhaps three breeding populations as of this writing. Although other as yet unknown populations probably exist, the dusky gopher frog is without doubt one of Alabama's rarest amphibians (Mount 1980).

Because of the small number of known populations, rapid decline in quantity and quality of breeding and non-breeding habitat, and its close

<sup>2</sup>Crawfish frogs, although never documented from Alabama, may ultimately be discovered in floodplain areas of Lamar and/or Pickens counties. Northern crawfish frogs (*R. areolata circulosa*) have been collected within ten miles of the state line in the vicinity of Columbus, Mississippi.



## Dusky gopher frog in Alabama

association with the threatened gopher tortoise, the dusky gopher frog is considered threatened in Alabama. Studies of its breeding cycle, population ecology, and larval ecology are needed to determine the seriousness of its status (Means 1986). The dusky gopher frog is currently listed by the U.S. Fish and Wildlife Service as a candidate Category 2 taxon, meaning a listing proposal for federal threatened or endangered status may be appropriate but that there is not yet enough evidence to support publication of a proposal. Fewer than 10 extant breeding populations are known. No gopher frogs have been seen in Louisiana in over 20 years. Mississippi has one known population, a few are scattered across the Florida panhandle, and one may still remain in Georgia. A recent decision by the U.S. Fish and Wildlife Service to fund a rangewide status survey should result in a better understanding of this species' conservation status.

The dusky gopher frog is one of several amphibians that breeds in temporary ponds during the winter and early spring in the southeastern Coastal Plain. Males apparently call from the water's surface, and submerged fist-sized egg masses are attached to vertical stems of emergent vegetation. Reproductive potential is high. One Escambia County gopher frog egg mass contained 1,709 eggs. Although the breeding period in Alabama typically is from late January to early April, some breeding occurred at Salt Pond in Conecuh National Forest in September and October of both 1988 and 1989 following heavy rainfall associated with hurricanes (pers. obs.). Other amphibians known to share breeding sites with the dusky gopher frog in Alabama include the southern leopard frog (*Rana sphenoccephala*), eastern tiger salamander (*Ambystoma tigrinum tigrinum*), mole salamander (*Ambystoma talpoideum*), dwarf salamander (*Eurycea quadridigitatus*), central newt (*Notophtalmus viridescens louisianensis*), northern spring peeper (*Pseudacris crucifer crucifer*), southern chorus frog (*Pseudacris nigrita nigrita*), and ornate chorus frog, (*pseudacris ornata*).

## RESEARCH

Pond-breeding amphibians such as gopher frogs are ideally suited to population studies because the adult population can be censused each year during arrival at the breeding site. The effectiveness of the pitfall trap/drift fence collecting technique, together with standard marking techniques, allows a direct monitoring of the movements of each individual in the breeding migration. Three limited studies have been conducted on dusky gopher frog populations in Alabama in 1985-86, 1988, and 1989-90, the results of which are briefly summarized below.

From 22 December 1985 to 23 March 1986, research was conducted at a shallow pond ("Gopher Pond") on private timber company property near Brewton in Escambia County, Alabama. Gopher frogs were collected, marked and released from pitfall traps along a plastic drift fence that completely encircled the breeding site. Traps were checked daily. A total of 269 gopher frogs, 93 males and 176 females, was captured during the study period. Seventy-five (80.6%) of the males were recaptured and 152 (86.4%) of the females were recaptured. For these animals, the mean

duration of occupancy of the pond per visit was 25.3 days for males and 9.2 days for females. Median occupancy was 26 and 3 days, respectively. Maximum number of days spent in the pond at a single visit was 59 males and 37 for females. Almost half of the males (46.4%) remained in the pond 30 days or more. Only 5.7% of the females remained this long. Migration to and from the breeding pond (and breeding activity) was positively correlated with rainfall and warming air temperatures. At least 128 egg masses were deposited during the study period, beginning on 25 January.

From 6 February to 23 March 1988, 31 gopher frogs (17 males, 12 females, 2 undetermined) were trapped, marked and released at Salt Pond in Conecuh National Forest (Covington County). This was only a partial sample of the adult breeding population, since an entire fence was not constructed and breeding activity occurred before, during and after the sampling period. Thirty-seven egg masses were counted in Salt Pond in 1988, and the earliest date of breeding (judging by egg mass deposition) was 27 or 28 February.

During the winter and spring of 1989-1990, a survey for the presence of gopher frogs in Conecuh National Forest (CNF) was conducted under a contract between the US Forest Service and the Alabama Natural Heritage Program. Principal objectives of the study were to monitor existing populations and to identify additional populations and/or breeding sites. Forty-nine ponds were assessed for gopher frog breeding habitat suitability in 1988, and those that appeared to be likely habitat were visited during the breeding period. Circumstantial evidence of breeding was found at one new site, but results are inconclusive. Breeding was confirmed at Salt and Nellie ponds (where 24 and 33 egg masses were found, respectively). The earliest egg masses (at Salt Pond) were probably deposited between 18 and 22 January. A single male was heard calling on three occasions (22 January, 7 and 21 February) at Yellow Hill Pond, a site that had not been known to support breeding gopher frogs since 1985. No egg masses were found in Yellow Hill Pond, however.

#### THREATS

Gopher frogs require suitable breeding and non-breeding habitat within reasonable proximity to each other (certainly no farther than a mile). Unfortunately, both habitat types (i.e., shallow, fishless, grassy ponds and natural longleaf pine-dominated uplands with gopher tortoises) are becoming scarce, and finding the two together is becoming more and more difficult. Threats to the gopher frog, then, include threats to both the upland habitat and the breeding ponds.

#### *Conversion of Natural Longleaf Forest to Plantations*

The dusky gopher frog is known only from natural communities dominated (or historically dominated) by longleaf pine. Conversion of natural longleaf pine forest to planted stands of off-site species such as slash pine (*Pinus elliotti*) and loblolly pine (*P. taeda*) is a major cause for the decline of longleaf and its associated species in the Southeast. The U.S. Forest Service (1988) has projected a decline in Alabama's timber

## Dusky gopher frog in Alabama

inventory on natural pine stands from 6.72 billion board feet in 1984 to 1.99 billion in 2030. Conversely, a seventy-fold increase is projected for the timber inventory on pine plantations from 99 million board feet in 1952 to 6.95 billion by 2030. The continuing trend in forest management away from natural stands toward intensively managed, maximum-yield plantations does not bode well for the gopher frog.

### *Fire Suppression*

Although prescribed burning (usually in the winter) is a valuable and widely used forest management tool, far fewer acres of forest burn today than in historic, and presumably, pre-Colombian times. Naturally occurring fires probably most frequently occurred across the Coastal Plain in the summer months, when the frequency of lightning strikes is the greatest. Until earlier in this century, local residents also regularly "burned off the woods" in the spring with the intent of controlling ticks and snakes and to improve grazing for free-ranging cattle. The U.S. Forest Service (1988) reports that on non-Federal (i.e., forest industry, private, state, and local government) timberland in the Southeast, 80,000 acres burned in 1983, only 1% of the 7.3 million acres that burned in 1925. This is 6% of the acreage that burned in 1940, 13% of that for 1950, and 27% of that for 1960. With the decreased frequency or absence of fires, the fire-adapted longleaf "fire subclimax" community gradually yields to hardwood encroachment. As the longleaf community disappears, so does the sandhill herpetofauna. An effort on the part of land managers to return to frequent burning at ecologically appropriate timing and intensity would no doubt greatly benefit the gopher frog as well as the entire spectrum of native flora and fauna of the longleaf pine ecosystem.

### *Introduction of Fish to Breeding Ponds*

The gopher frogs that bred as recently as 1985 at Yellow Hill Pond in Conecuh National Forest were apparently impacted by the introduction of green sunfish (*Lepomis cyanellus*), a fish that apparently halted virtually all amphibian reproduction at that formerly productive (and fishless) pond (pers. obs.). Most larger ponds in the Southeast that can support fish for more than a few years between droughts have probably been stocked with gamefish by local residents. Such artificial introductions of predatory fish can be expected to render a pond unsuitable for gopher frogs.

### *Road Construction*

Construction of roads can have direct and indirect effects on gopher frogs. Increased traffic can result in mortality from vehicles, and at least three Alabama specimens have been collected on roads. A Barbour County breeding pond was destroyed when a county highway was constructed directly on it (after it was drained). At least three ponds that currently support breeding gopher frogs are threatened by siltation from "wing ditches" designed to carry runoff from nearby graded dirt roads. Loads of silt are washed into the ponds with each heavy rain, reducing their water-holding capacity, altering vegetation, and generally hastening the demise of the pond, at least as a suitable gopher frog breeding site.



## Decline of the Gopher Tortoise

The degree to which gopher frogs depend upon the burrows of gopher tortoises is unknown. In Alabama, gopher frogs have been observed entering gopher tortoise burrows (pers. obs.), and they have been observed (via a remote video camera) inside burrows on several occasions. (R. Lohoefer, pers. comm.). The Shelby County gopher frogs occur well outside the current range of the tortoise, however. Other subspecies of gopher frogs have been found in oldfield mouse (*Peromyscus polionotus*) burrows, and dusky gopher frogs are probably no exception. Still, it is clear that gopher frogs benefit to some degree from the presence of tortoise burrows, and it is reasonable to assume that they may not fare as well in their absence. The gopher tortoise is continuing to decline on private lands in Alabama, largely due to changes to the upland habitats mentioned above. Additional threats to the gopher tortoise include the loss of habitat to urbanization and agriculture, predation by humans (a rural tradition apparently on the decline), and the introduction of toxic fumes into burrows by participants in "rattlesnake roundups", an activity that likely harms any occupant of the burrow, including gopher frogs.

## CONSERVATION AND MANAGEMENT RECOMMENDATIONS

Above all, the protection of existing gopher frog breeding ponds and adjacent uplands is critical to the continued existence of the species in Alabama. Three breeding sites are in Conecuh National Forest, where monitoring and habitat management is already being implemented. Managers of private lands should be informed of the presence of gopher frogs and encouraged to enter into conservation agreements to refrain from practices that may negatively affect gopher frog and gopher tortoise populations, especially within a half-mile radius or so from the pond.

Intensive surveys for previously unknown gopher frog populations should be conducted. Since 1985, three new breeding ponds have been found in Alabama. More undoubtedly exist, but they must be identified before they can be protected.

Additional research into basic life history, as well as larval ecology and population genetics, is needed. As an example, almost nothing is known about the distance gopher frogs will travel from a breeding pond. A Florida gopher frog was recovered at a tortoise burrow 2 km from the pond where it was marked (Franz, 1988), but the maximum distance gopher frogs range from their breeding pond is still unknown. Also unknown is the degree to which gopher frogs use tortoise burrows and other types of shelters. Radiotelemetry studies could answer these and other questions, enabling land managers to make informed decisions.

## LITERATURE CITED

- Altig, R., and R. Lohoefer. 1983. *Rana areolata*. Cat. Amer. Amphib. Rept. 324.1-324.4.
- Carr, A.F., Jr. 1940. A contribution to the herpetology of Florida. Univ. Fla. Publ. Biol. Sci. Ser. 3:1-118.



Dusky gopher frog in Alabama

- Collins, J.T., et al. 1990. Standard common and current scientific names for North American amphibians and reptiles. 3rd ed. SSAR Herp. Circular No. 19. 41 pp.
- Franz, R. 1988. *Rana areolata aesopus* (Florida gopher frog) life history note. Herp. Review 19:32.
- Guthrie, R.F. 1983. *Rana areolata sevosa* (dusky gopher frog) geographic distribution. Herp. Review 16:31.
- Means, D.B. 1986. Dusky gopher frog, pp. 30-31. In R.H. Mount (ed.), Vertebrate animals of Alabama in need of special attention. Alabama Agr. Exp. Sta., Auburn, Alabama. 124 pp.
- Mount, R.H. 1980. Survey for the presence or absence of threatened or endangered reptiles and amphibians, Conecuh National Forest, Alabama. Unpublished report to U.S. Forest Service.
- Redmond, W.H., Jr., and R.H. Mount. 1975. A biogeographic analysis of the herpetofauna of the Coosa Valley in Alabama. J. Ala. Acad. Sci. 46:65-81.
- U.S. Department of Agriculture, Forest Service. 1988. The South's fourth forest: alternatives for the future. Forest Service Report No. 22. Washington, D.C. U.S. Dept. of Agriculture, Forest Service. 512 pp.
- Wright, A.H. 1932. Life-histories of the frogs of Okefinokee Swamp, Georgia. New York, The McMillan Company. 497 pp.

A CONSERVATION PROGRAM FOR SEA TURTLES IN THE  
SOUTHEASTERN CONTINENTAL UNITED STATES<sup>1</sup>

Earl E. Possardt  
U. S. Fish and Wildlife Service  
3100 University Blvd. S.  
Jacksonville, FL 32216

INTRODUCTION

Five sea turtle species inhabit the coastal waters of the southeastern continental United States and all of them at least occasionally nest on its beaches. All are federally listed as either endangered or threatened under the Endangered Species Act of 1973, as amended (ESA) (Mager, 1985).

The loggerhead (*Caretta caretta*) is the most abundant nester with an estimated 50,000 nests deposited annually (unpubl. data from North Carolina Wildlife Resource Commission (NCWRC), South Carolina Wildlife and Marine Resource Commission (SCWMRD), Georgia Department of Natural Resources (GDNR), and Florida Department of Natural Resources (FDNR). This accounts for over one-fourth of the worldwide nesting of loggerheads and represents the second most important nesting rookery for this species in the world (Groombridge, 1982). Within the U.S. approximately 89% of loggerhead nesting activity occurs in Florida, 1.5% in Georgia, 8% in South Carolina, and 1.5% in North Carolina; negligible nesting also occurs along the Alabama, Mississippi, Louisiana, Texas and Virginia coasts. Ehrhart (1989), reviewed the status of the loggerhead and concluded the U.S. population is declining. Nesting data for South Carolina and Georgia support this conclusion (Frazer, 1983; Hopkins-Murphy, 1988). Nesting data for North Carolina and Florida are insufficient to draw general conclusions about nesting population trends.

The green turtle (*Chelonia mydas*) is the second most abundant nester in the southeastern United States. Nesting is largely restricted to the east coast of Florida from Brevard County south (Conley and Hoffman, 1987). Infrequent nesting has been recorded however, in Georgia, North Carolina, and the Florida panhandle (Crouse, 1985; FDNR, unpubl. data; GDNR, unpubl. data). Nesting activity varies greatly between years and ranged from 359-866 during the period 1979-1989 (Conley and Hoffman, 1987; FDNR, unpubl. data). Dodd (1981) reviewed nesting data for the period 1967-81 and believed the data provided evidence of an increasing population. The overall increase in the number of nests, however, can be attributed, at least partially, to an increase and improvement in survey

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coverage. Green turtle nesting also appears to be subject to wide natural fluctuations of several magnitudes between years due to environmental factors influencing reproductive conditions (Limpus, 1989). Consequently, while there was some evidence of increased nesting activity in the mid to later 1980's, survey areas were not consistent and the time frame was not long enough to draw meaningful conclusions.

Leatherback (*Dermochelys coriacea*) nesting is largely confined to the east coast of Florida with an isolated record from Blackbeard Island, Georgia and an unconfirmed report from North Carolina (Crouse, 1985; Seyle, 1985; Conley and Hoffman, 1987). Nesting activity is centered around Palm Beach County and nine to 125 nests were reported annually during the period 1979-89 (Conley and Hoffman, 1987; FDNR, unpubl. data). Lack of consistent and standardized nest survey methodology precludes any conclusions on nesting population status in Florida.

The hawksbill (*Eretmochelys imbricata*) is normally a tropical nester and nesting north of the Tropic of Cancer can be considered peripheral to its major nesting range in the Western Hemisphere. Consequently, it is a rare nester in the southeastern continental United States, with only one to two nests recorded annually in Florida (Lund, 1985; McMurtray and Richardson, 1985; Conley and Hoffman, 1987; FDNR, unpubl. data). Nesting has been documented in Volusia, Brevard, Martin, and Dade counties (Dalrymple et al., 1985; McMurtray and Richardson, 1985; FDNR, unpubl. data).

The Kemp's ridley (*Lepidochelys kempi*) nests almost entirely along a 30 km stretch of beach at Rancho Nuevo, Mexico. Between 1985 and 1989 the total number of nests at Rancho Nuevo ranged from 702-842 (U.S. Fish and Wildlife Service (USFWS), unpubl. data). One or two nests are reported each year on Padre Island, Texas, and in 1989 a female deposited a single clutch at Madiera Beach on Florida's southwest coast (FDNR, unpubl. data). Based on a film of a nesting arribada in 1947, it was estimated that 40,000 females nested during the 4 hour arribada (Hildebrand, 1981). Fewer than 400 females now nest throughout the entire season, giving this species the dubious distinction of being the most endangered sea turtle (USFWS, unpubl. data).

#### THREATS

An array of factors threaten sea turtles populations and habitat in the southeastern United States. While it is difficult to fully assess and quantify each individual threat, the relative importance of specific factors is discussed below. These factors are by no means all inclusive but do represent the major known or perceived threats and concerns.

**Beach armoring:** This includes various devices such as seawalls, rock revetments, sandbags, and bulkheads constructed on the beach or dunes to provide protection to human structures from erosion. These devices increase erosion and interfere with the natural migration of the beach, degrade nesting habitat and ultimately eliminate the nesting beaches in many instances. While most coastal states in the southeastern United

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States restrict or prohibit beach armoring, this destructive practice continues. For example, between January 1988 and June 1990, 78 permits for some type of armoring were issued by the State of Florida. This translates into the armoring of an estimated additional 2.4 km of Florida's coast. With an anticipated sea level rise of up to one-third of a meter by the year 2050, shorelines could recede up to 20 meters (Kerr, 1989), creating an enormous demand for additional beach armoring to protect homes, businesses, and roads.

*Beach renourishment:* The practice of placing sand on the beach is often a byproduct of a channel or inlet dredging project. It is also becoming an increasingly popular, although expensive, option for some communities to restore eroded beaches. An estimated 15-25 km of beach are renourished each year in the southeastern United States. If beaches are highly eroded and good quality sand is used the results can be beneficial to nesting turtles. Poor quality material can, however, result in a compacted beach which in turn will cause a greater frequency of aborted nesting attempts (Raymond, 1984). In some cases, shallow or aberrant egg chambers are dug and eggs overflow onto the beach, leading to the demise of the entire clutch (Raymond, 1984). Nesting females may also be subjected to increased physiological stress since digging time is increased on compacted nourished beaches (Nelson and Dickerson, 1989). Nests successfully deposited in compacted beaches may suffer reduced hatching success due to poor gas diffusion surrounding the egg chamber (Ackerman, 1980). When construction activities occur during the nesting season nests must be relocated to hatcheries. This may result in reduced hatching success and changes in incubation temperatures which in turn may skew hatchling sex ratios. nests are also missed and subsequently buried or crushed despite the best efforts of surveyors.

*Predation:* Raccoons and feral hogs are major causes of nest loss on many nesting beaches and without active nest protection programs an estimated 5,000 - 10,000 nests could be destroyed annually throughout the Southeast (Davis and Whiting, 1977; Schroeder, 1981; Stancyk, 1982; Labisky et al., 1986; USFWS, unpubl. data). On some important South Carolina and Florida nesting beaches over 90% of the nests would be destroyed by one or both of these predators without nest protection programs (Davis and Whiting, 1977; Stancyk et al., 1980; Schroeder, 1981; Labisky et al., 1986; USFWS, unpubl. data). Ghost crabs can be significant egg predators on some beaches but predation levels are difficult to quantify (Stancyk, 1982). Foxes and armadillos also prey on nests but their impacts for the most part are restricted to a few local sites and are not of regional significance (Stancyk, 1982; USFWS, unpubl. data).

*Erosion:* Tidal inundation and erosion can destroy or reduce the hatching success of hundreds of nests each year (Witherington, 1986; USFWS, unpubl. data). Hurricane Hugo destroyed an estimated 10-25% of the nests deposited in South Carolina in 1989 (USFWS, unpubl. data; S. Murphy, pers. comm.). Even without such severe storm events fewer than 25% of the 800-1200 nests deposited annually on Cape Island, South Carolina would hatch without nest relocation efforts because of the severely eroded beach



conditions (USFWS, unpubl. data). On a 21 km stretch south of Melbourne Beach, Florida however, where 25% of the nesting in the southeastern United States occurs, nest loss from these factors is minimal, barring a severe storm event. For example, in 1985 only 3.0% of a sample of marked loggerhead nests were destroyed by erosion or tidal inundation (Witherington, 1986).

*Artificial beachfront lighting:* After emergence, hatchling sea turtles orient and crawl towards the brightest horizon as their primary ocean finding cue (Mrosovsky, 1967; Dickerson and Nelson, 1988; Dickerson and Nelson, 1989; Witherington, 1989). Under the natural conditions which existed for millions of years this served them well. Now however, artificial lighting from coastal street lights, residences, businesses, and vehicular traffic on adjacent highways can dramatically alter light conditions and consequently misorient thousands of hatchlings each year (FDNR, unpubl. data). Once hatchlings enter the water their paths to pelagic destinations may be altered by direct lighting or by a lighting glow from densely developed coastal areas (Witherington and Bjorndal, in press a). Artificial lighting also has been demonstrated to significantly reduce nesting in lighted areas and can misorient those females that do nest after nesting is completed (Witherington, in review).

*Poaching:* While difficult to document, poaching of juvenile and adult sea turtles in the southeastern United States does not appear to be significant, particularly in comparison to the incidental take by commercial fisheries and dredging activities. Poaching of eggs while not uncommon is the least important cause of nest loss. During the period 1983-1989 the Florida Marine Patrol made 29 arrests for illegal possession of sea turtle eggs. While many egg poaching incidents undoubtedly go undetected, major commercial operations generally become known and terminated.

*Ingestion and entanglement of persistent marine debris:* Plastic and styrofoam and other persistent marine debris are frequently encountered in the marine environment by sea turtles and ingested either mistakenly as food or incidentally with food items. In Texas, 46% of 76 turtles necropsied had marine debris present in the gut (Plotkin and Amos, 1988). Items included plastic styrofoam, tar balls, monofilament fishing line, balloons, aluminum foil, and glass among other items. Except where there is complete blockage of the gut it is difficult to determine when ingested debris are a primary or contributing cause of death. More subtle and less detectable effects are more likely to occur such as reduced absorption of nutrients across the gut wall, absorption of toxic byproducts, and interference in energy metabolism or gut function (Balazs, 1985; Lutz, in press).

Sea turtles are frequently entangled in fishing lines, shrimp trawls, crab traps, and other discarded or lost ropes or fishing gear. Twenty-five (8.7%) of 287 turtles stranded along the south Texas coasts in 1986-87 were entangled by various ropes or nets (Plotkin and Amos, 1988). Of these, entanglement was believed to be the cause of death of 7 (28%).

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*Commercial fisheries:* Shrimp trawling is the single most important mortality factor for juvenile, subadult, and adult sea turtles in the southeastern United States. The National Marine Fisheries Service (NMFS) has estimated that over 47,000 sea turtles are captured annually with over 11,000 dying as a result. These estimates are based on over 27,000 observer hours on shrimp vessels. The Committee on Sea Turtle Conservation, appointed by the National Academy of Sciences, evaluated the NMFS data and concluded capture and mortality estimates were conservative and actual mortalities may have been as high as 50,000 loggerheads and 5000 Kemp's ridleys each year.

Trawl net fisheries for flounder in North Carolina, longline fisheries for tuna, gill and trammel net fisheries for shark, king mackerel, and pompano in Florida, and pound net fisheries in Virginia and North Carolina have all been implicated in the capture and mortality of sea turtles. The National Academy of Sciences' Committee on Sea Turtles Conservation estimated the combined mortality from all commercial fisheries other than shrimping is about one-tenth that of shrimping.

It is the survival of the juvenile and subadult stages which has the greatest effect on population growth (Crouse et al., 1987), and which explains why reductions in incidental take of these life stages is essential for sea turtle conservation.

*Dredging:* The death of 77 loggerhead turtles during the dredging of Canaveral Harbor in 1980 highlighted the problem of harbor and channel dredging in a dramatic way (Rudloe, 1981). Between 1980 and 1990, 149 sea turtle entrainments were recorded at Canaveral and Kings Bay dredging projects (Richardson, 1990). Most entrained turtles are killed although occasionally a small green turtle survives. The extent of mortality from other channel dredging projects is largely unknown but probably minor in comparison since Canaveral seems to be unique in its high concentration of turtles.

### CONSERVATION MEASURES

Basic to management of any threatened or endangered species is knowledge of population trends. Population trends are particularly difficult to determine for sea turtles. They are widely distributed in the marine environment and surface time is minimal and variable. Nesting activity is spread over 2200 km of beaches and varies independently from population size. Long generation times can also confound interpretation of the data. While recognizing the difficulties inherent in monitoring population trends with nesting surveys, they are still the only practical method available. In the past although ground survey coverage has been extensive throughout the Southeast, methodology and year to year coverage varied greatly and severely limited the usefulness of the data for regional nesting population trend analysis. Consequently, the USFWS, in conjunction with the FDNR, developed a standardized survey protocol with advice from sea turtle experts experienced in nesting survey methodology, and standardized ground nesting surveys were initiated on 28 index beaches

in Florida in 1989. These beaches encompassed approximately 90% of the nesting activity within the state. Projects were included based on known nesting densities, geographic distribution, and commitment to long term monitoring following the standardized protocol. In 1990, USFWS in cooperation with the NCWRC and GDNr, implemented standardized ground nesting surveys on 6 index beaches in North Carolina and 10 index beaches in Georgia. These beaches cover an estimated 75% of the nesting activity in each state.

SCWMRD has been monitoring nesting activity in South Carolina using aerial surveys since 1980. Surveys are conducted for 3 consecutive years with 2 non-survey year intervals and cover about 90% of the state.

*Beach armoring:* Several state and federal laws have been enacted to regulate coastal development and to protect the dune and beach system. These include the Coastal Barriers Resources Act of 1982 (federal), Coastal Areas Management Act of 1974 (North Carolina), Beachfront Management Act of 1988 (South Carolina), Shore Assistance Act of 1979 (Georgia) and Coastal Zone Protection Act of 1985 (Florida). While these laws were not specifically enacted to protect nesting habitat, their overall effect has been beneficial and slowed the rate of beach armoring.

Public ownership is the most effective means of protecting nesting habitat from such threats as beach armoring and coastal development. Currently, 25% of the nesting beaches in the southeastern United States are within federal or state ownership as parks, wildlife refuges, or military reservations. An estimated 20-25% of the nesting activity occurs on these beaches. The USFWS and State of Florida have recently taken steps to protect the highest density nesting beaches in the U.S. which occur along Florida's east central coast. The Archie Carr National Wildlife Refuge would encompass 16 km of coastline when completed and raise to 35% the amount of nesting activity on beaches within the public domain.

*Beach renourishment:* In the past construction activities were frequently scheduled during the summer to avoid adverse weather and sea conditions. Hundreds of nests were simply moved to hatcheries if necessary. Frequently poor quality material resulted in sand compaction and the nourished beaches remained hard until a major storm event removed it. Currently, state resource agencies and the USFWS require construction activities to occur outside the main part of the nesting and hatching season on important nesting beaches. If sand compaction exceeds 500 index units as measured by a cone penetrometer (a level determined not to effect nest digging times), the U.S. Army Corps of Engineers or the contractor must soften the beach by mechanical tilling to a depth of ca 90 cm.

*Predation/erosion:* The emphasis on nest protection efforts now is to employ the least manipulative technique so as to duplicate or maintain natural conditions. This policy is emphasized by the USFWS and state resource agencies to avoid possible adverse impacts such as reduced hatching success, skewing or natural sex ratios, and interference with the imprinting process. For example, where predation is the primary



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threat to nests, live trapping and removal can reduce nest losses from over 90% to 2-5% as it has at Merritt Island National Wildlife Refuge (USFWS, unpubl. data). Screening nests to keep out raccoons but still allow hatchling escapement has been employed at Canaveral National Seashore; it has reduced nest loss from over 90% to 55-60% (National Park Service, unpubl. data). Where erosion poses a serious threat, nests are relocated to safer locations on the same beach or if large numbers are involved, they are relocated to a self-release hatchery located high on the beach or in the foredunes. Throughout the southeastern United States over 60% of the nesting activity receives some form of nest protection. Tables 1 and 2, from the draft green and loggerhead turtle recovery plans, provide an overview of the major survey and protection projects. Data in these tables were provided by NCWRC, SCWMRD, GDNR, FDNR, and USFWS.

Table 1. Major green turtle nest survey/protection projects in Florida, 1985-88. (Modification of Table 1 from Draft Recovery Plan for U.S. Population of Atlantic Green Turtle, July 1990).

Project	Beach length (km)	# nests	Techniques*
Carnaveral NS	37.0	22-94	S/NS
Merritt Island NWR	9.6	13-25	S/PR
Canaveral AFS	21.0	6-24	S/PR
Patrick AFB	7.0	0-10	S
Melbourne Beach	21.0	6-281	S/PR
Sebastian Inlet SRA	4.8	7-35	S/NR
Hutchinson Island	36.5	45-74	S
St. Lucie SRA	3.8	7-17	S/PR
Hobe Sound NWR	5.7	3-30	S/PR
Town of Jupiter	12.1	45-62	S
J.D. MacArthur SP	2.9	9-35	S/PR
City of Boca Raton	5.6	2-22	S/NS/NR
Broward County Beaches	39.0	4-48	S/NR
Dade County Beaches	22.5	3-11	S/NR

- \* S - Survey  
 NS - Nest Screening  
 PR - Predator Removal  
 NR - Nest Relocation

*Artificial beachfront lighting:* In 1985, Brevard County, Florida enacted the first lighting ordinance in response to the growing awareness of the hatchling misorientation problem. Since then at least 7 other coastal counties and 20 cities in Florida have passed similar ordinances. Georgetown County, passed the first lighting ordinance in South Carolina. Guidelines approved under South Carolina's Beachfront Management Act of 1988 will eventually require all coastal communities to adopt lighting ordinances. Initially most ordinances prohibited direct lighting on the beach after 11:00 pm during the turtle nesting season (defined as May 1 -



Table 2. Major loggerhead nest survey/protection projects in the Southeastern U.S., 1985-1989. Includes consistently monitored survey areas reporting greater than 100 nests annually. Not all beaches surveyed during entire five year period. (Modification of Table 1 from Draft Recovery Plan for U.S. Population of Loggerhead Turtle, July 1990).

Project	Length (km)	# nests	Technique
Baldhead Island, NC	19.3	95-281	S/NR
Sand/South Islands, SC	8.0	111-373	S/NR/NS/PR
Cape Romain NWR, SC	8.0	796-1264	S/NR/PR
Kiawah Island, SC	15.0	84-176	S/NR/NS
Edisto Island, SC	18.3	111-289	S/NR/NS/PR
Otter Island, SC	4.3	70-195	S/NR/NS/PR
Hunting Island, SC	7.0	105-175	S/NR
Fripp Island, SC	6.0	51-176	S/NR/NS
Pritchard's Island, SC	4.0	57-176	S/NR/NS
Day Point, SC	5.0	143-195	S/NR/NS/PR
Hilton Head, SC	29.0	115-144	S/NR
Blackbeard Island NWR, GA	11.2	110-234	S/NR/NS/PR
Ossabaw Island, GA	15.2	56-114	S/NS/PR
Cumberland Island NS, GA	28.0	158-172	S
Flagler County Beaches, FL	29.0	75-206	S
New Smyrna Beach, FL	16.1	166-188	S/NR
Canaveral NS, FL	37.4	670-3331	S/NS
Merritt Island NWR, FL	9.6	993-1216	S/PR
Cape Canaveral AFB, FL	21.0	1284-1649	S
Patrick AFB, FL	7.0	923-1346	S
Melbourne Beach, FL	21.0	8864-10193	S/PR
Sebastian Inlet SRA, FL	4.8	513-863	S/PR
Wabasso Beach, FL	8.0	1197-1256	S
Vero Beach, FL	7.0	199-279	S/NR
Hutchinson Island, FL	36.5	4637-5496	S
St. Lucie Inlet SP, FL	4.3	289-432	S/PR
Hobe Sound NWR, FL	5.3	1202-1500	S/PR
Town of Jupiter, FL	12.1	2640-5848	S
Juno Beach, FL	8.1	2790**	S
J.D. MacArthur SP, FL	2.9	496-816	S/PR
Delray Beach, FL	3.5	138-177	S/NR
City of Boca Raton, FL	8.0	874-896	S/NR/NS
Broward County Beaches, FL	38.6	1244-1670	S/NR/NS
Miami Area Beaches, FL	16.9	64-162	S/NR
Manasota Key, FL	18.9	312-486	S/NR
Casey Key, FL	8.2	107-342	S/NR
Sanibel Island, FL	18.5	111-137	S
Wiggins Pass Beaches, FL	6.4	106-135	S/NS
Keewaydin Island, FL	7.2	96-111	S/NR/NS

\* S - Survey

NR - Nest relocation

NS - Nest screening

PR - Predator removal

\*\*1989 data only

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October 31). Recent data which demonstrate that 31% of hatchling emergences occurred prior to 11:00 pm on south Brevard County beaches (Witherington, in press b), has led to modification of several ordinances; most new ordinances now require 9:00 pm or dawn to dusk prohibition on direct lighting. Prevention of direct lighting is accomplished by turning lights off, shielding, or screening lights. Where lighting ordinances are enforced and complied with such as in south Brevard County, dramatic decreases in hatchling misorientation have occurred (Witherington, 1986).

In response to significant lighting problems identified at Canaveral Air Force Station, Florida, the Air Force in consultation with the USFWS has developed or is developing light plans for all of its launch complexes and industrial areas. These plans will phase in substantial modifications to existing lighting to reduce or eliminate impacts to turtles.

The USFWS interprets the misorientation of hatchlings as "take" under the ESA, and as such will investigate and prosecute individuals or others whose lights can be demonstrated to cause misorientation.

*Poaching:* The "take" of sea turtles or their eggs is illegal under ESA and state laws except when authorized by appropriate agencies for scientific, propagation, or educational purposes. State and federal wildlife or fisheries officers from the USFWS, NMFS, and state resource agencies routinely investigate and arrest violators. Federal civil penalties can be as high as \$25,000 for each violation, while ESA also provides for criminal penalties of up to \$50,000 and imprisonment of up to one year.

*Ingestion and entanglement of persistent marine debris:* Annex V of the International Convention for Prevention of Pollution from Ships was ratified by the United States on December 31, 1987. The Coast Guard published an interim rule in the Federal Register on May 30, 1989, implementing provision of Annex V. Compliance with this rule will reduce the amount of plastics, including synthetic fishing nets, and other ship-generated garbage intentionally discharged into the marine environment.

*Commercial Fisheries:* The promulgation and implementation of federal regulations requiring the shrimping industry to use turtle excluder devices (TEDs) in their trawls was the single most important sea turtle conservation accomplishment in the last decade. These rules first went into effect at Canaveral, Florida on October 1, 1987, but subsequent political actions and court challenges resulted in intermittent and delayed implementation and enforcement throughout the Southeast until October 15, 1989.

The present rule requires all vessels 25 feet or longer to use a TED in offshore waters as follows: in the Canaveral Area, year-round; in the Atlantic Area from North Carolina to south Florida (excluding the Canaveral Area), May 1- August 31; southwest Florida, year-round; the remaining Gulf of Mexico, March 1- November 30. Shrimp trawlers less than 25 feet in length must limit tow times to 90 minutes or alternatively use a TED. Shrimp trawlers of all sizes must either restrict tow times to 90

minutes or use a TED in inshore waters at times when TED requirements are in effect for adjacent offshore waters.

South Carolina has state Ted regulations in effect similar to the federal regulations while Florida has implemented year-round regulations in all state waters (boats with nets with a headrope size of 35 feet or less are except in inshore waters). The State of Georgia is developing state TED requirements which expand on the federal regulations and which should be in force by the 1991 shrimping season.

*Dredging:* All dredging projects are subject to review and consultation by the NMFS under the authority of Section 7 of ESA. As a result, extensive surveys have been funded by the Corps of Engineers and the U.S. Navy to determine the distribution and abundance of sea turtles at the St. Mary's and Canaveral entrance channels in Georgia and Florida. The resulting data are used to determine dredging windows which are least likely to cause turtle mortality. In addition, the Corps has been conducting extensive research to develop a draghead which will eliminate or minimize turtle deaths. In the meantime, all channel dredging projects which utilize hopper dredges are required to filter material and hire onboard observers to monitor and record turtle mortality.

*Research:* Recent research accomplishments in the Southeast include determination of natural loggerhead sex ratios (Provancha and Mrosovsky, 1988), hatchling emergence times in east central Florida (Witherington, in press b), internesting habitat use and behavior of adult female loggerheads in South Carolina, and the effects of artificial lights on hatchling and adult green and loggerhead turtles (Witherington, in review). An increasing emphasis is being placed on "in the water" studies, and juvenile distribution and abundance surveys are underway in Texas, Florida, and North Carolina.

Since 1980, a voluntary network was established by the NMFS to monitor mortality by recording sea turtle strandings. In 1987, four index zones were established in an attempt to systematically survey strandings to improve the usefulness of the data for trend analysis. While the primary purpose of the network is to document temporal and geographic distribution, strandings also provide an invaluable source of material for basic biological studies.

#### LITERATURE CITED

- Ackerman, R. A. 1980. Physiological and ecological aspects of gas exchange by sea turtle eggs. *Amer. Zool.* 20:575-583.
- Balazs, G. H. 1985. Impact of ocean debris on marine turtles: entanglement and ingestion, p. 387-429. In R. S. Shomura, and H. O. Yoshida (eds.). *Proceedings of the workshop on the fate and impact of marine debris*, 26-29 November 1984, Honolulu, Hawaii. NOAA Tech. Memo. NMFS/SWFC-54.
- Conley, W. J. and B. A. Hoffman. 1987. Nesting activity of sea turtles in Florida, 1979-1985. *Fla. Sci.* 50:201-210.



## Conservation program for sea turtles

- Crouse, D. 1985. The biology and conservation of sea turtles in North Carolina. PhD. Dissertation. University of Wisconsin, Madison.
- Crouse, D. T., L. B. Crowder, and H. Caswell. 1987. A stage-based population model for loggerhead sea turtles and implications for conservation. *Ecology* 68:1412-1423.
- Dalrymple, G. H., J. C. Hampp, and D. J. Wellins. 1985. Male-biased sex ratio in a cold nest of hawksbill sea turtle (*Eretmochelys imbricata*). *J. Herpetol.* 19:158-159.
- Davis, G. E. and M. C. Whiting. 1977. Loggerhead sea turtle nesting in Everglades National Park, USA. *Herpetologica* 33:18-28.
- Dickerson, D. D., and D. A. Nelson. 1989. Recent results on hatchling orientation responses to light wavelengths and intensities, p. 41. In S. A. Eckert, K. L. Eckert, and T. H. Richardson (compilers), *Proceedings of the ninth annual workshop on sea turtle conservation and biology*. NOAA Tech. Memo. NMFS-SEFC-232.
- Dickerson, D. D., and D. Nelson. 1988. Use of long wavelength lights to prevent disorientation of hatchling sea turtles, p. 19-21. In B. A. Schroeder (compiler), *Proceedings of the eighth annual workshop on sea turtle conservation and biology*. NOAA Tech. Memo., NMFS-SEFC-214.
- Dodd, C. K. Jr. 1981. Nesting of the green turtle, *Chelonia mydas* (L), in Florida: historic review and present trends. *Brimleyana* 7:39-54.
- Ehrhart, L. M. 1989. Status report of the loggerhead turtle, p. 122-144. In L. Ogren, F. Berry, K. Bjorndal, H. Kumpf, R. Mast, G. Medina, H. Reichart, and R. Witham (eds.), *Proceedings of the second Western Atlantic turtle symposium*, NOAA Tech. Memo. NMFS-SEFC-226.
- Frazer, N. B. 1983. Survivorship of adult female loggerhead sea turtles, *Caretta caretta*, nesting on Little Cumberland Island, Georgia, USA. *Herpetologica* 39:436-447.
- Groombridge, B. (compiler). 1982. The IUCN Amphibia-Reptilia red data book. Part 1. Testudines, Crocodylia, Rhynchocephalia. IUCN, Gland, Switzerland, 426 pp.
- Hildebrand, H. 1981. A historical review of the status of sea turtle populations in the western Gulf of Mexico, p. 447-453. In K. A. Bjorndal (ed.), *Biology and conservation of sea turtles*. Smithsonian Institution Press, Washington, D.C.
- Hopkins-Murphy, S. 1988. Status of the loggerhead in South Carolina, p. 35-37. In B. A. Schroeder (compiler), *Proceedings of the eighth annual workshop on sea turtle conservation and biology*. NOAA Tech. Memo. NMFS-SEFC-214.



- Kerr, R. A. 1989. Bringing down the sea level rise. Res. news (Dec.):1563.
- Labisky, R. F., M. A. Mercadante, and W. L. Finger. 1986. Factors affecting reproductive success of sea turtles on Cape Canaveral Air Force Station, Florida, 1985. Final Report to the U. S. Air Force, U. S. Fish and Wildl. Serv., Fish and Wildl. Research Unit, Agreement No. 14-16-0009-1544, Work Order No. 25, 18 p.
- Limpus, C. J. 1989. Environmental regulation of green turtle breeding in eastern Australia., p. 93-95. In S. A. Eckert, K. L. Eckert, and T. H. Richardson (compilers). Proceedings of the ninth annual workshop on sea turtle conservation and biology. NOAA Tech. Memo. NMFS-SEFC-232.
- Lund, F. P. 1985. Hawksbill turtle (*Eretmochelys imbricata*) nesting on the east coast of Florida. J. Herpetol. 19:164-166.
- Lutz, P. L. in press. Studies on the ingestion of plastic and latex by sea turtles. Proc. Int. Conf. Mar. Debris, April 1989, Honolulu, HI.
- Mager, A. Jr. 1985. Five-year status reviews of sea turtles listed under the Endangered Species Act of 1973. NMFS, Washington, D.C.
- McMurtray, J. D., and J. I. Richardson. 1985. A northern nesting record for the hawksbill turtle. Herp. Rev. 16(1):16-17.
- Mrosovsky, N. 1967. How turtles find the sea. Sci. J. (Nov.):2-7.
- Nelson, D. A., and D. D. Dickerson. 1989. Effects of beach nourishment on sea turtles, p. 125-27. In S. A. Eckert, K. L. Eckert, and T. H. Richardson (compilers), Proceedings of the ninth annual workshop on sea turtle conservation and biology. NOAA Tech. Memo. NMFS-SEFC-232.
- Plotkin, P., and A. F. Amos. 1988. Entanglement in and ingestion of marine debris by sea turtles stranded along the south Texas coast, p. 79-82. In B. A. Schroeder (compiler), Proceedings of the eighth annual workshop on sea turtle biology and conservation NOAA Tech. Memo. NMFS-SEFC-214.
- Provancha, J. A., and N. Mrosovsky. 1988. Sex ratio of loggerhead sea turtles hatching on a Florida beach in 1986. In B. A. Schroeder (compiler), Proceedings of the eighth annual workshop on sea turtle conservation and biology. NOAA Tech. Memo. NMFS-SEFC-214.
- Raymond, P. W. 1984. The effects of beach restoration on marine turtles nesting in south Brevard County, Florida. MS Thesis. University of Central Florida, Orlando.

## Conservation program for sea turtles

- Richardson, J. I. 1990. The sea turtles of the King's Bay area and the endangered species observer program associated with construction dredging of the St. Marys Entrance ship channel., p. 32-46. In D. A. Dickerson, and D. A. Nelson (compiler), Proceedings of the national workshop on methods to minimize dredging impacts on sea turtles. Misc. Paper EL-90-5, U.S. Army Eng. Waterways Exp. Station, Vicksburg, Miss.
- Rudloe, J. 1981. From the jaws of death. Sports Illus. 54(13):60-70.
- Schroeder, B. a. 1981. Predation and nest success in two species of marine turtles (*Caretta caretta* and *Chelonia mydas*) at Merritt Island, Florida. Fla. Aci. 44(1):35.
- Seyle, C. W. Jr. 1985. Correction of the northernmost leatherback nesting on the U.S. Atlantic coast. Herp. Rev. 16(2):38.
- Stancyk, J. E. 1982. Non-human predators of sea turtles and their control, p. 139-152. In K. A. Bjorndal (ed.), Biology and conservation of sea turtles. Smithsonian Institution Press, Washington, D.C.
- Stancyk, S. E., O. R. Talbert, & J. M. Dean. 1980. Nesting activity of the loggerhead *Caretta caretta* in South Carolina, II. Protection of nests from raccoon predation by transplantation. Biol. Conserv. 18:289-298.
- Witherington, B. E. 1989. Beach lighting and the seaward orientation of hatchling sea turtles, p. 189-190. In S. A. Eckert, K. L. Eckert, and T. H. Richardson (compilers), Proceedings of the ninth annual workshop on sea turtle conservation and biology. NOAA Tech. Memo. NMFS-SEFC-232.
- Witherington, B. E. 1986. Human and natural causes of marine turtle clutch and hatchling mortality and their relationship to hatchling production on an important Florida nesting beach. M.S. Thesis. University of Central Florida, Orlando.
- Witherington, B. E., and K. A. Bjorndal. in press a. Orientation of hatchling loggerhead turtles at sea off artificially lighted and dark beaches. J. Exp. Mar. Biol. Ecol.
- Witherington, B. E., and K. A. Bjorndal. in press b. Temporal pattern of nocturnal emergence of loggerhead turtle hatchlings from natural nests. Copeia 1990.
- Witherington, B. E., and K. A. Bjorndal. in review. Behavioral responses of nesting sea turtles to artificial lighting. Herpetologica.

WHALES AND DOLPHINS OFFSHORE OF ALABAMA<sup>1</sup>

Keith Mullin, Ren Lohoefer<sup>2</sup>, Wayne Hoggard,  
Carolyn Rogers, Carol Roden  
National Marine Fisheries Service  
P. O. Drawer 1207  
Pascagoula, MS 39568

and

Brian Taggart  
NOAA Aircraft Operations Center  
P. O. Box 020197  
Miami, FL 33102

INTRODUCTION

All whales, dolphins and porpoises (cetaceans) in United States (U.S.) waters are protected by the Marine Mammal Protection Act of 1972. The Act, except under special circumstances, places a moratorium on killing, capturing, harassing or hunting marine mammals in U.S. waters and on importing marine mammals and marine mammal products into the U.S. (Hofman 1989). Eight species of large whales, depleted by whaling, are listed as endangered under the provisions of the Endangered Species Act of 1973.

At least 77 species of cetaceans occur throughout the world. These species include 11 baleen whales (Balaenidae, Balaenopteridae, Eschrichtiidae), three sperm whales (Physeteridae), the narwhal and white whale (Monodontidae), 18 beaked whales (Ziphiidae), 32 small whales and oceanic dolphins (Delphinidae), six porpoises (Phocoenidae), and five river dolphins (Platanistidae) (Leatherwood and Reeves 1983).

Knowledge of the distribution, abundance and seasonality of cetacean species in the Gulf of Mexico (Gulf) is generally poor, even though the Gulf is a relatively small body of water with populated coasts. Until recently, except for studies of coastal bottlenose dolphins (Leatherwood and Reeves 1982, Shane et al. 1986), knowledge of cetaceans in the Gulf has come from strandings (found dead or alive on the shore), opportunistic sightings (Schmidly 1981) and a series of aerial surveys conducted by Fritts et al. (1983) offshore of southern Texas, western Louisiana and southern Florida. These sources indicate at least 29 species of cetaceans have occurred in the Gulf (Table 1). These include seven baleen whales, all three sperm whales, four beaked whales and 15 smaller whales

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<sup>2</sup>Present address: U.S. Fish and Wildlife Service, Jackson Mall Suite 316, 300 Woodrow Wilson Avenue, Jackson, MS 39213.

Table 1. Cetaceans of the Gulf of Mexico

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Balaenidae	
Right whale	<i>Eubalaena glacialis</i> *
Balaenopteridae	
Blue whale	<i>Balaenoptera musculus</i> *
Fin whale	<i>B. physalus</i> *
Sei whale	<i>B. borealis</i> *
Bryde's whale	<i>B. edeni</i>
Minke whale	<i>B. acutorostrata</i>
Humpback whale	<i>Megaptera novaeangliae</i> *
Physeteridae	
Sperm whale	<i>Physeter macrocephalus</i> *
Pygmy sperm whale	<i>Kogia breviceps</i>
Dwarf sperm whale	<i>K. simus</i>
Ziphiidae	
Cuvier's beaked whale	<i>Ziphius cavirostris</i>
Blainville's beaked whale	<i>Mesoplodon densirostris</i>
Sowerby's beaked whale	<i>M. bidens</i>
Gervais' beaked whale	<i>M. europaeus</i>
Delphinidae	
Melon-headed whale	<i>Peponocephala electra</i>
Pygmy killer whale	<i>Feresa attenuata</i>
False killer whale	<i>Pseudorca crassidens</i>
Killer whale	<i>Orcinus orca</i>
Short-finned pilot whale	<i>Globicephala macrorhynchus</i>
Rough-toothed dolphin	<i>Steno bredanensis</i>
Fraser's dolphin	<i>Lagenodelphis hosei</i>
Common dolphin	<i>Delphinus delphis</i>
Bottlenose dolphin	<i>Tursiops truncatus</i>
Risso's dolphin	<i>Grampus griseus</i>
Atlantic spotted dolphin	<i>Stenella frontalis</i>
Pantropical spotted dolphin	<i>S. attenuata</i>
Striped dolphin	<i>S. coeruleoalba</i>
Spinner dolphin	<i>S. longirostris</i>
Clymene dolphin	<i>S. clymene</i>

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\* - endangered



## Whales and dolphins offshore of Alabama

and oceanic dolphins. Porpoises, the narwhal and white whale are not known in the Gulf. They are generally found only in cold waters in higher latitudes. Except for one species, river dolphins are found only in large river systems in South America, India, Pakistan and China.

The bottlenose dolphin (*Tursiops truncatus*) appears to be the dominant cetacean in continental shelf waters of the Gulf (generally <200 m deep), although some species of *Stenella* may occur more frequently in Florida shelf waters (Fritts et al. 1983, Scott et al. 1989, Mullin et al. in press). The extensive continental shelf in the Gulf (up to 280 km wide) is one reason that deep water cetaceans are poorly known.

Cetacean studies in deep Gulf waters are expensive and logistically difficult. However, human activities (e.g., minerals development, fishing, and vessel traffic) are increasing in deep Gulf waters. How these activities affect cetaceans is unknown. Because of the lack of knowledge of cetaceans in deep Gulf waters, in cooperation with the U.S. Minerals Management Service, we conducted aerial surveys to study cetaceans along the continental slope south of the Alabama, Mississippi and Louisiana coasts during 1989 and 1990.

Our purpose here is to, using our own work and that of others, briefly review the species and distribution of cetaceans which may be encountered in the Gulf offshore of Alabama.

### METHODS

Because of the limited size of the Alabama coast and the long distance to the edge of continental shelf, where cetacean diversity increases, we defined waters offshore of Alabama as those waters within a 300 km radius of its shore including waters we surveyed during aerial surveys from July 1989 through June 1990. We reviewed available sources of data for sightings and strandings of cetaceans within this 300 km radius. We used the following sources:

1. Schmidly (1981) - This report reviews all sightings and strandings of cetaceans in the Gulf reported in the scientific literature and from unpublished records. This report and Fritts et al. (1983) are the most comprehensive references on Gulf of Mexico cetaceans.
2. Scientific literature since Schmidly (1981) and data from our colleagues who share our interest in Gulf cetaceans also provided us with sighting and stranding information.
3. The monthly aerial surveys we conducted in an area from 87°30.0' to 91°00.0' east to west and from the 200 m isobath seaward 50 km (Figure 1). Water depths in this area range from 200 to 1,850 m.

### RESULTS AND DISCUSSION

Of the 29 cetacean species which have occurred in the Gulf, only five had not stranded or were not sighted offshore Alabama. These include

the right whale, blue whale, minke whale, melon-headed whale and Fraser's dolphin. There are only two records each of both the right whale and blue whale from other regions of the Gulf. The minke whale maybe more common in the Gulf. Four minke whales have stranded along Gulf shores and there are five stranding records from the Florida Keys (Schmidly 1981). The first record of the melon-headed whale was from a stranding in Texas in 1990 (D. Odell pers. comm., Sea World of Florida). The only record of Fraser's dolphin the Gulf is from a mass stranding on the Marquesas Keys west of Key West, Florida (Hersh and Odell 1986).

We found 24 species of cetaceans which had either stranded or had been sighted offshore of Alabama. Because deep Gulf waters have not been well studied and because strandings are poor indicators of offshore abundance, it is premature to draw conclusions with confidence regarding the relative abundance of each species in the Gulf. Based on Schmidly (1981) and our aerial survey, we arbitrarily defined a species as "rare" which has fewer than six stranding or sighting records with the 300 km radius of Alabama; "uncommon," six to ten records; and "common," more than ten records. During our aerial surveys, we sighted 342 herds of cetaceans. However, some herds could only be identified as unknown cetaceans. For each species, we give the number of herds which were sighted. The length of each species as reported by Leatherwood and Reeves (1983) is given. Details of the biology and ecology of each species is beyond the scope of this paper but additional information can be found in Schmidly (1981), Fritts et al. (1983) or Gaskin (1982). In general, however, the baleen whales are filter feeders which prey on krill (in cold waters), plankton and small fish. The sperm whales, beaked whales, pygmy killer whale, false killer whale, short-finned pilot whale and Risso's dolphin are thought primarily to prey on squid. The killer whale will feed on pinnipeds, fish and other cetaceans including baleen whales. The diets of other dolphins are believed to consist mainly of fish (Gaskin 1982). The following cetaceans have stranded or have been sighted offshore of Alabama:

*Fin whale* (24 m, uncommon) - Of the baleen whales, the fin whale, an endangered species, has the most records. There have been two recent sightings from aerial surveys. One was sighted in July 1985 (L. Hansen pers. comm., NMFS Miami). We sighted a fin whale in November 1989.

*Sei whale* (17 m, rare) - The sei whale, an endangered species, is known only from strandings. However, we sighted a baleen whale June 1990 that was either a sei whale or a Bryde's whale. The two species are similar in many respects and are difficult to distinguish from a distance.

*Bryde's whale* (14 m, rare) - Bryde's whale was not recognized as a distinct species until 1878. Bryde's whales are found in warm waters throughout the world and there may be a resident Gulf population (Leatherwood and Reeves 1983). Since 1987 there have been at least two live strandings of Bryde's whale on the Louisiana coast west of the Mississippi River.

*Humpback whale* (16 m, rare) - The humpback whale, an endangered species, is known only from sightings records. We did not sight any humpback whales during aerial surveys.

## Whales and dolphins offshore of Alabama

*Sperm whale (12-15 m, common)* - Sperm whales, an endangered species, have been commonly sighted and have also stranded. Prior to 1920, sperm whales were killed by whalers in deep waters between the Mississippi River delta and DeSoto Canyon (Townsend 1935, Lowery 1974). During aerial surveys, we sighted 44 herds of sperm whales ranging from one to 11 whales (Figure 1). Some of the herds contained calves. We sighted sperm whales during every month except December (no surveys were conducted) and February. Sperm whales may also be common in other parts of the Gulf. Fritts et al. (1983) reported sighting ten herds of sperm whales off the Texas coast during aerial surveys.

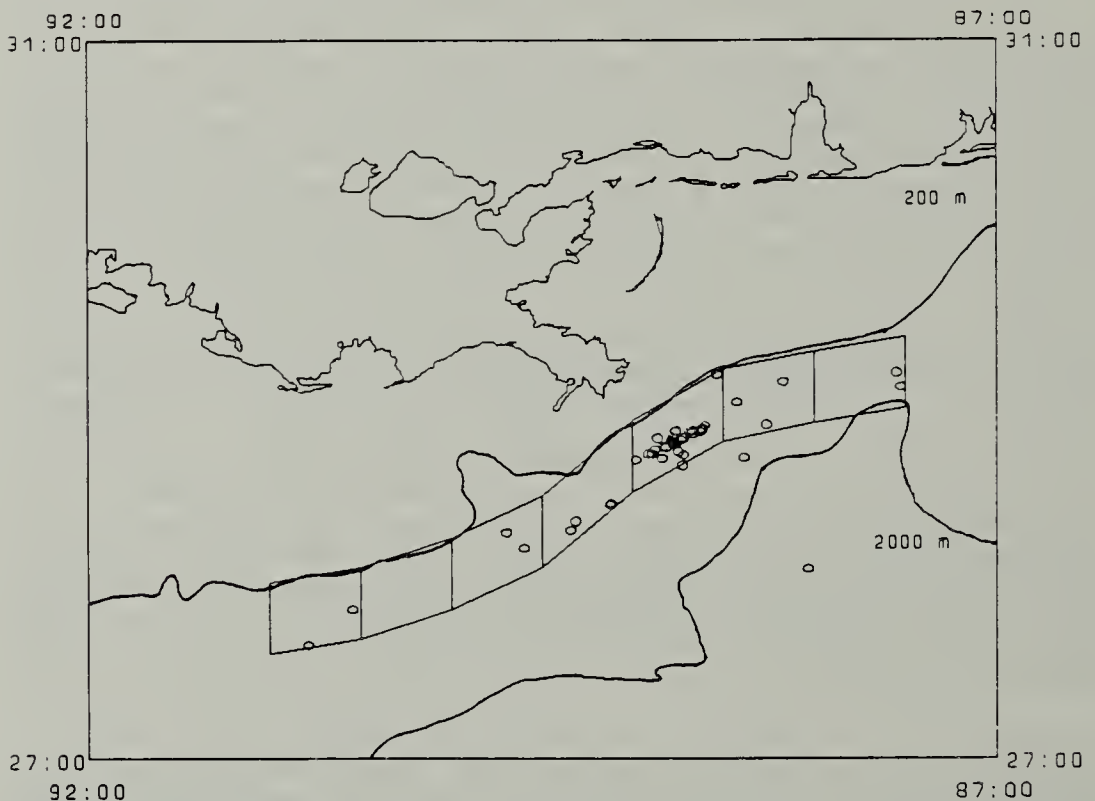


Figure 1. Locations of sperm whales herds (o) sighted during aerial surveys in seven contiguous study areas from July 1989 through June 1990 (effort in each area was not equal).

*Pygmy 3.4 m) and dwarf (2.7 m) sperm whales* - Based on stranding records each of these two species of small whales would be considered rare offshore of Alabama. However, our aerial survey data indicate dwarf or pygmy sperm whales are more common. In nine survey months, we sighted thirty-four herds of dwarf or pygmy sperm whales (Figure 2). The mean herd size was two whales. We cannot distinguish between the two species from the air. For the entire Gulf the stranding records indicate the pygmy sperm whale is common and the dwarf sperm whale uncommon. Many of these strandings were on the Texas coast. However, Fritts et al. (1983) reported sighting only one of these whales from their aerial surveys off southern Texas.

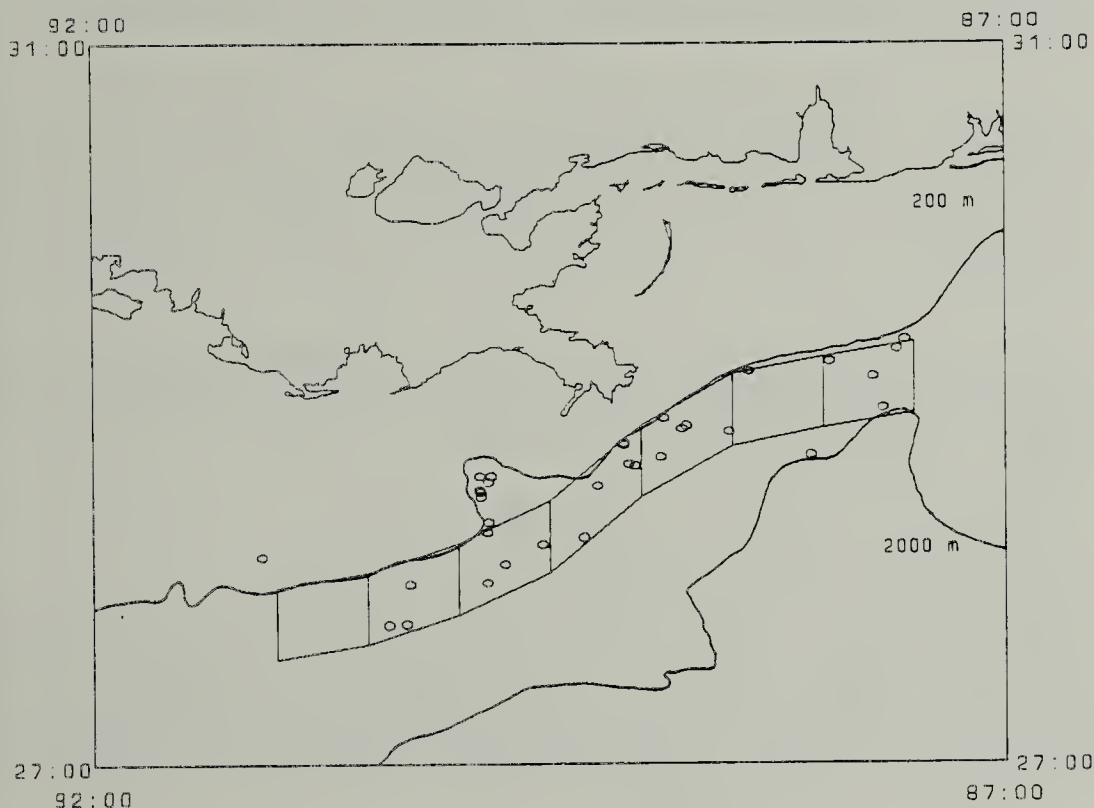


Figure 2. Locations of dwarf or pygmy sperm whale (o) herds sighted during aerial surveys (some surveys were conducted outside the seven areas).

*Cuvier's* (7.5 m), *Blainville's* (4.7 m), *Sowerby's* (5 m), and *Gervais'* (5 m) beaked whales - Each of these species is known from strandings near Alabama but each is rare. The only record of *Sowerby's* beaked whale from the Gulf is of a stranding on the Florida panhandle (Bonde and O'Shea 1989). We observed 11 beaked whales in nine sightings and during aerial surveys. *Cuvier's* beaked whale is the only species we could distinguish from the air. Based on its shape and white head, we identified three beaked whales as *Cuvier's* beaked whale. All the beaked whales we encountered seemed to be very timid. They usually sound very soon after the aircraft passes over them, allowing for only brief observations.

*Pygmy killer whale* (2.7 m, rare) - We sighted this species on two occasions during aerial surveys. The herd sizes were nine and 25 individuals. However, the pygmy killer whale is very similar in appearance to the melon-headed whale, the two species could easily be confused from an aircraft.



## Whales and dolphins offshore of Alabama

*False killer whale* (5.5 m, rare) - There were no strandings records of this whale. We sighted one herd of three and one of four whales during aerial surveys.

*Killer whale* (7-9.5 m, rare) - There was only one stranding record of a killer whale. However, there have been two recent sightings of pods of killer whales. In 1989, fishermen sighted and video taped a pod in deep water south of the Alabama-Florida border (R. Shipp pers. comm., Univ. South Alabama). In 1990, we sighted a pod of eight southwest of the Mississippi River delta. This pod included a young calf and a large adult male.

*Short-finned pilot whale* (5.4 m, common) - Records consist of both strandings and sightings. Of the six herds we sighted during aerial surveys, four were sighted during November 1989 and averaged about 18 animals. We sighted a herd in June with over 60 animals. Each herd we sighted contained calves.

*Rough-toothed dolphin* (2.8 m, rare) - These dolphins are known from one aerial sighting of three individuals and a stranding.

*Common dolphin* (2.3 m, rare) - This dolphin is known only from sightings offshore of Alabama. Schmidly (1981) reports only one stranding for the entire Gulf of Mexico. During our aerial surveys, we identified dolphins with certain characteristics as common dolphins until spring 1990. At that time we obtained video tape and photographs taken from ships of dolphins with the similar characteristics. These dolphins turned out to be pantropical spotted dolphins.

*Bottlenose dolphin* (3.9 m, common) - The bottlenose dolphin is found in nearly all available marine environments in the Gulf. On the continental shelf these habitats include salt marshes, sounds, bays, rivers outlets and open Gulf waters. While it is apparently more numerous on the continental shelf (<200 m), the bottlenose dolphin also occurs in deep Gulf waters of the continental slope and beyond. We sighted 38 herds during our aerial surveys that averaged 12 individuals. Studies of bottlenose dolphins offshore of Alabama include a study of behavior from Mobile Point (Goodwin 1985) and a study of abundance and ecology in and near Chandeleur Sound (Mullin 1988). Bottlenose dolphins are captured for military, research and public display purposes. Because the area offshore of Alabama is the site of the largest live-capture fishery of bottlenose dolphins in North America (Reeves and Leatherwood 1984), many studies of bottlenose dolphin abundance have been conducted. These studies include Leatherwood (1978), Thompson (1982), Scott et al. (1989) and Lohoefer et al. (1990). Most of the dolphins are captured in Mississippi Sound.

*Risso's dolphin* (4.0, common) - Until recently Risso's dolphins were thought to be rare in the Gulf. There were only three records for the entire Gulf, one of which was near Alabama. Jennings (1982) reported five sightings in Gulf waters. Risso's dolphin herds were the most frequently sighted cetacean during our aerial surveys and were sighted during nine different months. We sighted 61 herds that averaged about 13 individuals each (Figure 3).

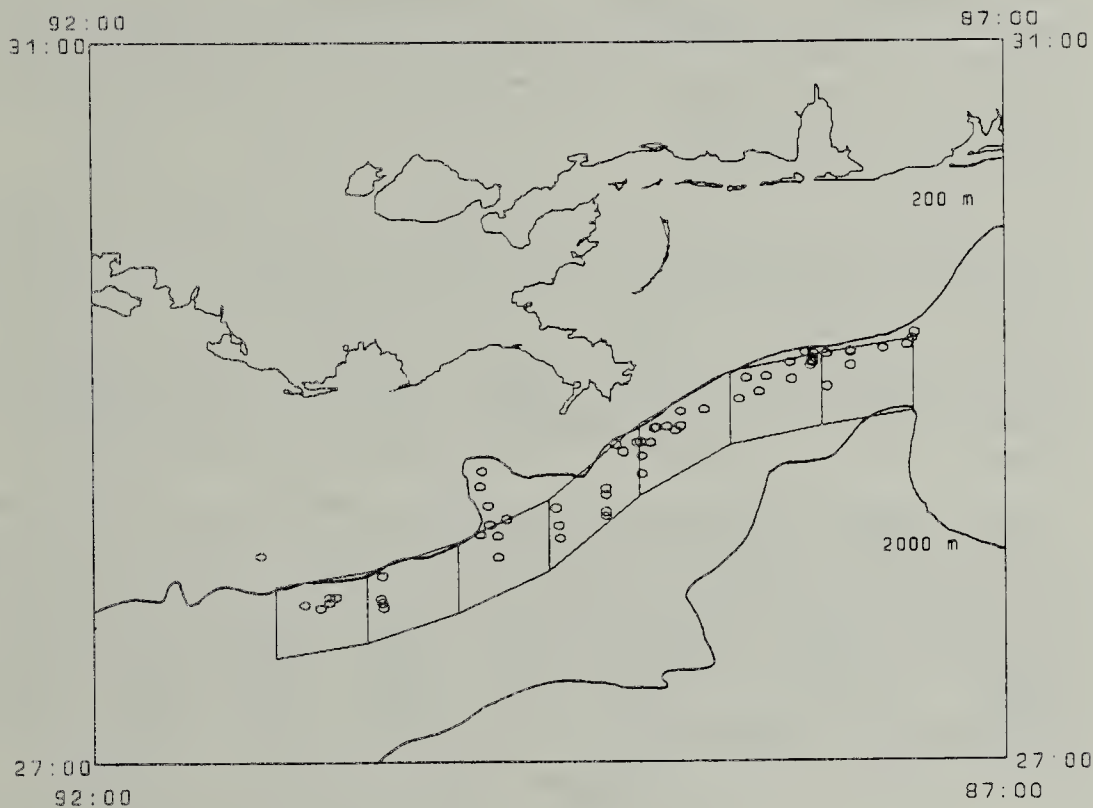


Figure 3. Locations of Risso's dolphins herds (o) sighted during aerial surveys.

*Atlantic spotted dolphin (2.5 m, common)* - This dolphin illustrates that stranding rates are not indicative of offshore abundance. Only two stranding records were recorded of the Atlantic spotted dolphin. However, there have been numerous sightings of this species. Fritts et al. (1983) thought that Atlantic spotted dolphins were the most common deep water cetacean in the Gulf. In nine different months, we sighted a total of 37 herds that averaged 35 individuals.

*Pantropical spotted dolphin (2.3 m, common)* - Schmidly (1981) did not list the pantropical spotted dolphin as occurring in the Gulf but listed records of a spotted dolphin called the bridled dolphin. Perrin et al. (1987) subsequently have revised the taxonomy of the spotted dolphins and concluded that many of the bridled dolphin records were pantropical spotted dolphins and some were Atlantic spotted dolphins. However, there were only two bridled dolphin records from other regions of the Gulf. Recently, the pantropical spotted dolphin has stranded near the Alabama coast (D. Odell pers. comm.) and during aerial surveys we sighted 31 herds of pantropical spotted dolphins that averaged 64 dolphins.

## Whales and dolphins offshore of Alabama

*Striped dolphin* (2.7 m, common) - No strandings of this species were reported. Recently, however, in both 1989 and 1990 a striped dolphin stranding has occurred on the Alabama coast (G.T. Regan pers. comm., Springhill College, Mobile). Striped dolphins were sighted during six months of our aerial study. We observed a total of 17 herds with an average herd size of 61.

*Spinner dolphin* (2.0 m) and *Clymene dolphin* (2.0 m) - Based on strandings both of these species would be considered rare. The only stranding near Alabama of the Clymene dolphin was a 1985 mass stranding on the Louisiana coast after Hurricane Juan (Harris 1986). These species are difficult to separate from the air. However, of the 11 herds we sighted, based on photographs, one herd was identified as spinner dolphins and one as Clymene dolphins. One of us (Roden) positively identified Clymene dolphins from the NOAA ship R/V OREGON II in deep water due south of the Alabama coast. These dolphins averaged just over 100 dolphins per herd.

In summary, stranding and sighting records indicate Gulf waters offshore of Alabama supports a diverse cetacean fauna that consists of at least 24 species including four endangered species. Although more study is needed before firm conclusions are drawn, our aerial surveys indicates that at least some of the species (i.e., sperm whale, Risso's dolphin, bottlenose dolphin, Atlantic spotted dolphin, pantropical spotted dolphins, and dwarf or pygmy sperm whales) have a wide spatial distribution in these waters and are found throughout the year.

### LITERATURE CITED

- Bonde, R. K. and T. J. O'Shea. 1989. Sowerby's beaked whale (*Mesoplodon bidens*) in the Gulf of Mexico. *Journal of Mammalogy* 70:447-449.
- Fritts, T. H., A. B. Irvine, R. D. Jennings, L. A. Collum, W. Hoffman, and M. A. McGehee. 1983. Turtles, birds, and mammals in the northern Gulf of Mexico and nearby Atlantic waters. U.S. Fish and Wildlife Service, Division of Biological Services, Washington, DC FWS/OBS-82/65. 455 pp.
- Gaskin, D. E. 1982. The ecology of whales and dolphins. Heinemann, London and Portsmouth, New Hampshire. 459 pp.
- Goodwin, D. E. 1985. Diurnal behavior of *Tursiops truncatus*, near Mobile Point, Alabama. MS thesis. San Francisco State University, San Francisco. 57 pp.
- Harris, S. A. 1986. Beached. *Louisiana Conservationist* 38:18-22.
- Hersh, S. L. and D. K. Odell. 1986. Mass stranding of Fraser's dolphin, *Lagenodelphis hosei*, in the western North Atlantic. *Marine Mammal Science* 2:73-76.
- Hofman, R. J. 1989. The Marine Mammal Act: A first of its kind anywhere. *Oceanus* 32:21-25.

- Jennings, R. 1982. Pelagic sightings of Risso's dolphin, *Grampus griseus*, in the Gulf of Mexico and Atlantic Ocean. *Journal of Mammalogy* 63:522-523.
- Leatherwood, S. and R. R. Reeves. 1982. Bottlenose dolphin and toothed cetaceans. Pages 369-414 in J. A. Chapman and G. A. Feldhamer (eds.), *Wild mammals of North America*. The Johns Hopkins University Press, Baltimore and London.
- Leatherwood, S. and R. R. Reeves. 1983. *The Sierra Club handbook of whales and dolphins*. Sierra Club Books, San Francisco. 302 pp.
- Lohoefer, R., W. Hoggard, K. Mullin, R. Ford and J. Benigno. 1990. Estimates of bottlenose dolphin density in Mississippi Sound. Report to the U.S. Marine Mammal Commission, 1825 Connecticut Avenue NW, Suite 512, Washington, DC 20009. 27 pp.
- Lowery, G. H., Jr. 1974. *The mammals of Louisiana and its adjacent waters*. Louisiana State University Press, Baton Rouge. 565 pp.
- Mullin, K. D., R. R. Lohoefer, W. Hoggard, C. L. Roden and C. M. Rogers. in press. Abundance of bottlenose dolphins, *Tursiops truncatus*, in the coastal Gulf of Mexico. *Northeast Gulf Science*.
- Mullin, K. D. 1988. Comparative seasonal abundance and ecology of bottlenose dolphins (*Tursiops truncatus*) in three habitats of the north-central Gulf of Mexico. Ph.D. dissertation, Mississippi State University, Mississippi State. 135 pp.
- Perrin, W. F., E. D. Mitchell, J. G. Mead, D. K. Caldwell, M. C. Caldwell, P. J. H. van Bree and W. H. Dawbin. 1987. Revision of the spotted dolphins, *Stenella* spp. *Marine Mammal Science* 3:99-170.
- Schmidly, D. J. 1981. *Marine mammals of the southeastern United States and the Gulf of Mexico*. U.S. Fish and Wildlife Service, Office of Biological Services, Washington, DC FWS/OBS-80/41 163 pp.
- Scott, G. P., D. M. Burn, L. J. Hansen, and R. E. Owen. 1989. Estimates of bottlenose dolphin abundance in the Gulf of Mexico from regional aerial surveys. NMFS-SEFC Miami Laboratory, 75 Virginia Beach Drive, Miami, FL 33149.
- Shane, S. H., R. S. Wells, and B. Wursig. 1986. Ecology, behavior and social organization of the bottlenose dolphin: a review. *Marine Mammal Science* 2:34-63.
- Thompson, N. B. 1982. Estimates of abundance of *Tursiops truncatus* in: St. Joseph-Apalachicola Bays, Florida; Mississippi Sound, Mississippi; and the Aransas-Copano-San Antonio Bay complex, Texas. Report to the National Marine Fisheries Service, Southeast Fisheries Center, Miami, Florida. 26 pp.



Whales and dolphins offshore of Alabama

Townsend, C. H. 1935. The distribution of certain whales as shown by logbook records of American whaleships. *Zoologica* 19:3-59.





## INSTRUCTIONS TO AUTHORS

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# THE JOURNAL OF THE ALABAMA ACADEMY OF SCIENCE

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COVER PHOTOGRAPH: Southeastern myotis, *Myotis austroriparius*. Once present over much of Alabama, this species now is irregular in distribution and its population size is unknown. Careless use of pesticides and destruction of habitat probably have caused the reduction in numbers and distribution of the southeastern myotis and several other species of bats. Unfortunately, ignorance and superstitions (e.g., bats are blind, have a high incidence of rabies, suck blood from your neck, or get tangled in your hair) have contributed to a lack of concern for their conservation. In fact, bats have keen eyesight (and sophisticated sonar), an incidence of rabies <0.05%, a diet composed of insects, and bats can make a right-angle turn within a distance of <7.5 cm--while flying at 80 km/h. Bats are especially beneficial to humans in removing insect pests (e.g., one gray bat in Alabama, *Myotis grisescens*, can consume 3,000 mosquitoes each night), and the chances of becoming infected by rabies from a bat is less than that of being killed by a bee sting, lightning, a power mower, or a dog attack. The open mouth of one of the bats shown here indicates it is emitting ultra-sonic sounds that will be reflected from objects and detected by the bat's sensitive sonar system.

Research on the southeastern myotis and other bats in Alabama is being conducted by Dr. Troy L. Best and several students, including Jarel L. Bartig, Stephanie L. Burt, Katharine G. Caesar, Rachel Chambers, Travis Hill Henry, Clayton D. Hilton, and Bettie A. Milam, from the Department of Zoology and Wildlife Science, Auburn University, Alabama. Photograph courtesy of Travis Hill Henry.

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ABSTRACTS

Papers presented at the 68th Annual Meeting  
Jacksonville State University  
Jacksonville, Alabama  
March 6-9, 1991

BIOLOGICAL SCIENCES

Larval settlement and juvenile survival in the red abalone (Haliotis rufescens): an examination of inductive cues and settlement substrates. Marc Slattery, Dept. of Biology, Univ. of Alabama at Birmingham.

Settlement and metamorphosis of red abalone, Haliotis rufescens, larvae was examined in the presence of three inductive settlement cues (conspecific mucous, a sympatric diatom assemblage, and  $\beta$ -aminobutyric acid). Larval settlement success differed significantly with substrate type. Mucous from juvenile H. rufescens yielded the highest levels of successful larval settlement. Larval settlement success varied and was highest between August and mid-September when examined from late Spring (May) to early Winter (December). Larval metamorphosis and juvenile survival to appearance of the first respiratory pore also varied with substrate type. After 11 weeks, approximately 53, 84, and 100% of the larvae had suffered mortality on substrates of conspecific mucous and diatoms, diatoms, and  $\beta$ -aminobutyric acid and diatoms, respectively. High larval settlement rates and survival of juvenile H. rufescens on substrates of conspecific mucous indicate this inductive cue may be of significance *in situ* as well as offering a convenient methodology for the rearing of red abalone in mass culture systems.

THE RARE DRAGONFLIES OF ALABAMA: AT RISK OR UNSTUDIED? Ken Tennesen, Tennessee Valley Authority, Aquatic Biology Department, Muscle Shoals, AL 35660.

Three species of Odonata on the proposed Federal Endangered Species list are known to occur in northern Alabama: Gomphus consanguis in Blount County, Gomphus septima in Tuscaloosa County, and Ophiogomphus incurvatus alleghaniensis in Blount and Tuscaloosa County. Several other species of possible concern on the state level include Arigomphus maxwelli, Gomphus modestus, Gomphus viridifrons, Stylurus amnicola, S. notatus, and Somatochlora georgiana. Most of these species require relatively undisturbed small to large streams or undisturbed wetlands to complete their life cycles. Several historic records are from sites greatly altered by damming or pollution. Whether any of these species are truly endangered within the state is unknown, as very little effort has been devoted to their study.



## Abstracts

### STRUCTURAL ASPECTS AND IMPLICATIONS OF TONGUE MORPHOLOGY OF THE NINE-BANDED ARMADILLO, DASYPUS NOVEMCINCTUS.

Doug Elrod and Robert Sikes, Memphis State University, Memphis, TN. 38152. William R. Bowen, Jacksonville State University, Jacksonville, AL 36265. Barry H. Good, Gary Heidt and Tina Green, University of Arkansas at Little Rock, Little Rock, AR 72204.

Since its initial presence in southernmost Texas, the nine-banded armadillo, Dasypus novemcinctus, has spread throughout most of southern United States. Like many introduced species, it is free of normal population controls--predators, parasites and competitors. The armadillo is also known for its bony skin with ossified plates and a litter of four, each being identical and of the same sex, due to their derivation from a single fertilized egg. The armadillo is a "rooter" and thus rather disruptive to its habitat. This study, using light and scanning electron microscopy, examines the adaptation of the armadillo's tongue to its foraging behavior. The tongue surface is characterized by an array of filiform papillae, fungiform papillae, and circumvallate papillae. The distal tip of the tongue bears a pair of probe-like, highly modified filiform papillae that previously have not been described in the literature. The functional implications of these surface features in the armadillo tongue will be discussed.

### THE STATUS OF THE BALD EAGLE HACKING PROGRAM IN ALABAMA. M. Keith Hudson, Nongame Wildlife Program, Alabama Department of Conservation and Natural Resources, Montgomery, AL 36130.

In 1985 the Alabama Nongame Wildlife Program initiated a project to restore nesting bald eagles Haliaeetus leucocephalus (Aves: Falconiformes) to Alabama. Goals are to restore 20 pairs of nesting eagles statewide. Thirty-five bald eagles were released from hacking towers at the Mud Creek Wildlife Management Area in northeast Alabama through spring 1989. Two eagles were released at the Bon Secour Wildlife Area in south Alabama in spring 1990. In spring 1991, 54 eagles will be released from 4 separate sites in west-central and southwest Alabama. The last successful bald eagle nest in Alabama known to have fledged birds was reported in 1964. Three active eagle nests were located in 1991, though it is likely that these nests were not established by hacked birds. Nesting activity from hacked eagles is expected to begin in 1992.

## Abstracts

STATUS OF RARE FISHES OF THE TENNESSEE RIVER DRAINAGE IN NORTHERN ALABAMA, WITH PARTICULAR EMPHASIS ON RECOVERY. Peggy W. Shute, Tennessee Valley Authority, Regional Natural Heritage Program.

Remnants of large river habitat, extensive cave systems and numerous springs in the "southern bend" of the Tennessee River drainage are habitats to which five federally protected fish species have become specialized, including: Speoplatyrhinus poulsoni, Alabama cavefish (Endangered); Etheostoma wapiti, boulder darter (E); E. boschungii, slackwater darter (Threatened); Percina tanasi, snail darter (T); and Cyprinella monacha, spotfin chub (T). Recovery and restoration of Alabama populations of some of these rare species is promising due to recent transplant and captive breeding activities. Of the four snail darter transplant attempts, at least two may have been successful. Present status of other populations is unclear and few recent specimens have been reported. Success of recent spotfin chub reintroductions in Tennessee may lead to restoration of Alabama populations of this species. Boulder darters are presently retained in the USFWS Gainesville laboratory in a captive breeding attempt. Success may lead to additional Alabama populations. Recent successful transplants of the spring pygmy sunfish, Elassoma sp. (Endangered in Alabama and a federal candidate), have expanded the range of this extremely localized species and lessens the necessity for federal protection. Present status of the Cypress Creek slackwater darter population is unclear. Alabama cavefish were last noted November 1983. A 1985-6 extensive cave survey failed to locate additional populations. The recharge area for the aquifer supplying the cave has been defined, allowing for land use and management decisions.

INDUCTION OF THE ACROSOME REACTION IN MICE BY IMMUNO-AGGREGATION OF A PROTEINASE INHIBITOR. David Aarons, Holly Boettger-Tong, Ginger Holt, Gary R. Poirier, Dept. of Biology, Univ. of Ala. at Birmingham, 35294.

A low molecular weight, acid stable proteinase inhibitor of seminal vesicle origin (SVI) binds to the acrosomal cap region of murine sperm at ejaculation (Irwin et al, 1983). The SVI-binding site participates in zona binding subsequent to the removal of the inhibitor at capacitation. Murine fertilization requires sperm binding to ZP3, a zona pellucida component. Once bound, ZP3 induces the acrosome reaction by the aggregation of the zona binding sites on the sperm head. This study is an attempt to induce the acrosome reaction by immuno-aggregation of SVI bound to the sperm head. Treatment of capacitated sperm with SVI and a rabbit antiserum to SVI results in a 50% increase in acrosome reacted sperm over the normal rabbit serum control, as determined by the Coomassie brilliant blue staining technique. Substituting the anti-SVI FAB fragment does not cause acrosome reactions. However, aggregation of the bound FAB by anti-rabbit IgG will induce the acrosome reaction. The data 1) indicate that the acrosome reaction can be induced by immuno-aggregation of SVI bound to the sperm head and 2) support the suggestion that SVI binds to the same site as does ZP3.

## Abstracts

### A BIOCHEMICAL AND HISTOCHEMICAL STUDY OF NUTRIENT STORAGE ENERGETICS AND GROWTH IN THE GUT OF THE SEA URCHIN LYTECHINUS VARIEGATUS.

Charles D. Bishop and Stephen A. Watts, Dept. of Biology, Univ. of Alabama at Birmingham, Birmingham, AL 35294.

Previously starved Lytechinus variegatus were fed a 5% fish meal-agar diet ad libitum for 32 days. The stomach wet weight increased by 60% by day 32; the large intestine wet weight increased by 41%, suggesting that both are short-term nutrient storage organs. The ratio of stomach mass:large intestine mass increased from 0.76 to 1.10 by day 32. This stomach:large intestine ratio may be used as an important indicator of the nutritional well-being of L. variegatus. DNA analysis and histological examination revealed that the growth of the gut was the result of a combination of increasing cell size and number. The concentration of lipid in the stomach increased 29%, but did not increase in the large intestine within 32 days. The total amount of lipid increased by 72% and 34% in the stomach and large intestine, respectively in 32 days. The total amount of protein in the stomach and large intestine also showed similar changes, increasing by 57% and 32% respectively within 32 days. These data suggest that the gut of L. variegatus exhibits significant increases in biochemical composition with feeding in a very short time. These changes enrich the nutritional storage capacity of the gut, and may reflect the individuals physiological well-being and the quality of the environment they inhabit.

### COMPARATIVE DIETARY EFFECTS OF Artemia ON DEVELOPMENT AND SURVIVORSHIP OF Macrobrachium rosenbergii LARVAE. Mark E. Meade and George B. Cline, Dept. of Biology, Univ. of Ala. at Birmingham, U.A.B. University Station, Birmingham, AL 35294.

Two strains of Artemia nauplii from different geographical areas (Columbia and San Francisco Bay) were evaluated as potential diets for Macrobrachium rosenbergii larvae. Previous studies indicate that these strains of Artemia contain relatively similar protein and carbohydrate content but vary significantly in fatty acid content. M. rosenbergii larvae from a single hatch were split into two groups and maintained in 200 liter closed-cycle systems with associated biofilters. Larvae were fed either of the two strains of freshly hatched Artemia (10-15 nauplii/ml). Larvae reared on Artemia nauplii containing the largest amounts of Omega-3 fatty acids (Columbian strain) developed to post-larvae in 20 days and demonstrated an overall survivorship of approximately 60%. Those larvae reared on Artemia nauplii containing relatively low amounts of Omega-3 fatty acids (San Francisco Bay strain) developed to post-larvae in 28 days and demonstrated overall survivorship of approximately 10%. We postulate that these differences in developmental rates and survivorship may be the result of the differential fatty acid content of the two strains of Artemia.



ASPECTS OF REPRODUCTION IN SELECTED ECHINODERMS OF THE NORTHERN GULF OF MEXICO. Gottfried O. Schinner, James B. McClintock, Stephen A. Watts, Ken Marion, The University of Alabama at Birmingham, AL 35294, and Thomas S. Hopkins, The University of Alabama and the Marine Environmental Science Consortium, AL 36528.

Three asteroids, *Astropecten articulatus*, *Athenoides piercei* and *Tosia parva* were collected approximately monthly between December 1988 and January 1991 from two sites located off the coast of Alabama and Florida. Sufficient gonadal samples were taken to allow an assessment of both the timing and magnitude of annual gametic production. Reproductive maturity was evaluated both on the basis of the gonadal index and histological examination of the gonad. *Astropecten articulatus* and *Athenoides piercei* showed planktotrophic modes of reproduction, characterized by large numbers of small eggs. Histological analyses revealed egg sizes of 30-200 and 20-200  $\mu\text{m}$ , respectively. *Tosia parva* had large eggs (100-800  $\mu\text{m}$  diameter), reflecting a lecithotrophic mode of reproduction. *Astropecten articulatus* was reproductively mature in winter 88 (Dec) and gonad indices peaked in winter 90 (Jan, Feb) and 91 (Jan). Gonad indices were low during summer. *Athenoides piercei* was reproductively mature in late fall (Nov, 89), while few mature gonads were noted during 1990. *Tosia parva* had peak reproductive indices during summer months of 1989, while producing fewer gametes in summer 1990. Gonadal indices were generally low during winter months. The reproductive cycle of all three asteroids varied markedly over the years 1989 and 1990. Gamete production occurred in all species but was significantly reduced and delayed in 1990. A likely explanation is that minimum sea water temperatures were 4 °C lower in the northern Gulf of Mexico during winter 1990 (15 °C) compared to the winter of 1989 (19 °C). The three species examined in the present study are at the extreme northern limits of their geographic distribution and may therefore be particularly vulnerable to temperature depression. Supported by a NSF EPSCoR Grant # R11-8996152 to J.B.M and T.S.H. G.O.S. was supported in part by an Austrian Schroedinger Postdoctoral Fellowship.

The Role of Attachment in the Survival of *Pseudomonas aeruginosa* After Lethal Exposure to Iodine. Matthew L. Brown\* and Joseph J. Gauthier, Univ. of Alabama at Birmingham, AL 35294.

When an antimicrobial agent such as iodine is added to stored potable water at concentrations shown to be lethal to bacteria in laboratory tests, many species are able to survive. The method by which these microorganisms survive is not completely understood but some researchers link the phenomenon to the ability of some bacteria to attach and grow on surfaces within the water system. In this study, the role of attachment to surfaces in the survival of *Pseudomonas aeruginosa* after exposure to a lethal concentration of PVP-iodine was examined. Bacterial attachment was induced by filtering viable bacteria under low vacuum pressure onto the surface of .2  $\mu\text{m}$ , white, polycarbonate membranes (Nucleopore) and then placing the membranes onto the surface of nutrient agar plates and incubating the plates for 0 to 96 hours. Betadine®, a commercially available 10% polyvinylpyrrolidone-iodine solution, was selected as the source of iodine. The membranes were exposed to a concentration of Betadine®, previously shown to be lethal to *Pseudomonas aeruginosa*, and then determinations of viable recovery from the membranes were made by spread-plating. It was found that significant viable recovery, greater than 35%, after exposure to a lethal concentration of Betadine® occurs after attachment to the surface of membranes for 24 hours or more. No viable recovery was found when cells were exposed to the same concentration of Betadine® in a broth suspension or after being filtered onto the surface of a membrane but not allowed to grow attached. It can be concluded that attachment to surfaces plays an important role in the survival of bacteria after exposure to lethal levels of iodine.



## Abstracts

CEDAR GLADES OF NORTHERN ALABAMA: ARE THEY WORTH SAVING? David H. Webb, Tenn. Valley Authority, Muscle Shoals, AL 35660, and Jerry M. Baskin and Carol C. Baskin, School of Biol. Sci., Univ. of Kentucky, Lexington, KY 40506

Cedar glades are natural openings that occur where limestone bedrock is at or near the surface. They are dominated by herbaceous annuals and perennials, with redcedar often growing around the edges. In northern Alabama, cedar glades are most common in the Moulton Valley; a few also occur in the Sequatchie Valley. Nineteen plant taxa considered critical in maintaining floristic diversity in Alabama occur in cedar glades. Delphinium alabamicum, Leavenworthia alabamica var. alabamica, L. a. var. brachystyla, L. crassa var. crassa, L. c. var. elongata, and Lesquerella lyrata are endemic to Alabama. Lesquerella lyrata is a federal threatened species, Dalea foliosa is proposed for listing as endangered, and Astragalus tennesseensis, Leavenworthia alabamica var. brachystyla, L. crassa var. crassa, L. c. var. elongata, L. exigua var. lutea, and Talinum calcaricum are under federal review. Almost all cedar glades in northern Alabama are privately owned. Many of them have been badly abused, and grazing, row cropping, right-of-way maintenance, and development threaten most of the others. Without conservation efforts, cedar glade habitat in Alabama will continue to decline, and several members of the state's native flora may be lost. Acquisition of selected glade systems and management easements with private landowners will help preserve a piece of Alabama's natural heritage. It is time to act!

INDUCTION OF THE ACROSOME REACTION IN MURINE SPERM BY IMMUNO-AGGREGATION OF A PROTEINASE INHIBITOR. David Aarons, Holly Boettger-Tong, Ginger Holt, Gary R. Poirier, Dept. of Biology, Univ. of Alabama at Birmingham, 35294.

A low molecular weight, acid stable proteinase inhibitor of seminal vesicle origin (SVI) binds to the acrosomal cap region of murine sperm at ejaculation (Irwin et al., 1983). The SVI-binding site participates in zona binding subsequent to the removal of the inhibitor at capacitation. Murine fertilization requires sperm binding to ZP3, a zona pellucida component. Once bound, ZP3 induces the acrosome reaction by the aggregation of the zona binding sites on the sperm head. This study is an attempt to induce the acrosome reaction, in the absence of ZP3, by immuno-aggregation of SVI bound to the sperm head. Treatment of capacitated sperm with SVI and a rabbit antiserum to SVI results in a 50% increase in acrosome reacted sperm over the normal rabbit serum control, as determined by the Coomassie brilliant blue staining technique. Substituting anti-SVI Fab fragment does not cause acrosome reactions. However, aggregation of the bound Fab by anti-rabbit IgG will induce the acrosome reaction. The data 1) indicate that the acrosome reaction can be induced by immuno-aggregation of SVI bound to the sperm head and 2) support the suggestion that SVI binds to the same site as does ZP3.

PRELIMINARY STUDIES ON ASPECTS OF THE FORAGING ECOLOGY OF *ASTROPECTEN ARTICULATUS* (ASTEROIDEA: ECHINODERMATA) FROM THE NORTHERN GULF OF MEXICO. Steven D. Beddingfield, James B. McClintock and Ken Marion, Dept. of Biology, Univ. of Alabama at Birmingham, and T. S. Hopkins, The Univ. of Alabama at Birmingham, Birmingham, AL 35294, and The Marine Environmental Science Consortium, Dauphin Island, Alabama 36528.

Prey items of *Astropecten articulatus* were investigated by examining the stomach contents of individuals collected by trawl from the northern Gulf of Mexico. Cumaceans, bivalves, mysids and gastropods were the most abundant prey species represented. The mean size of prey was 4.0 mm, ranging from 0.2 to 14.0 mm. Each sea star contained approximately 6 identifiable prey taxa in addition to detrital material. Prey size selectivity was investigated in the laboratory by presenting individuals ( $\bar{x}$  R = 49 mm) with three sizes (0.5, 1.0, 1.5 cm diameter) of circular food models composed of a mixture of 5% fish meal in Plaster of Paris. Individuals presented with equal amounts of food models (i.e. 20 small, 10 medium and 5 large) showed a significant preference for the smallest sized prey. No large models were ingested. Individuals offered equal numbers of different sized prey models also demonstrated a preference for smaller sized food models, but ingested larger numbers of medium sized models. Sea stars presented only large sized prey ingested these food models, indicating an ability to handle larger prey. Average handling times for small, medium and large sized models were 1.8, 6.0, and 10.7 min, respectively. Size selective feeding may be attributed to the ease of manipulation of smaller sized prey, which maximizes food intake per unit time. Mechanical constraints associated with morphological characteristics of mouth parts may determine the maximal sized prey which can be ingested. Supported by EPSCoR NSF grant #R11-8996152.

SALINITY TOLERANCE OF THE LESSER BLUE CRAB CALLINECTES SIMILIS. Pan-wen Hsueh and James B. McClintock. Dept. of biology, University of Alabama, Birmingham, AL 35294. Tom S. Hopkins, Marine Environment Science Consortium, Dauphin Island, AL 36528.

Survivorship of small (< 30 mm CW) and large (> 70 mm CW) Callinectes similis exposed to various salinities was examined in the laboratory. Crabs were kept in partitioned aquaria at 5, 10, 15, 20, 25, or 30 ppt salinity for one week. Daily mortality was monitored in all salinity treatments. After one week, surviving crabs were transferred into 1 ppt seawater and mortality recorded after 24 hours. With the exception of small crabs held in 15 ppt seawater, both sizes of crabs held in 5 ppt seawater suffered significantly greater mortality. There was no significant difference in the mortality of large crabs among 10, 15, 20, 25, and 30 ppt salinity treatments. Among small crabs, no significant mortality differences occurred among 10, 20, 25, and 30 ppt salinity treatments. Surviving crabs placed in 1 ppt seawater suffered almost 100% mortality within 24 hours. These results suggest that both juvenile and adult crabs cannot tolerate salinity lower than 5 ppt. This corresponds with observations that C. similis do not occur at Dauphin Island Airport Marsh from December to April, when salinities are generally low. This research was supported by a Student Research Award from Alabama Academy of Sciences and funds from the Mississippi-Alabama Sea Grant Consortium (Grant # NA89AA-D-SG016).



## Abstracts

PROTEIN BIOSYNTHESIS IN MANDUCA SEXTA PROTHORACIC GLANDS: STIMULATION BY BIG PROTHORACICOTROPIC HORMONE. Peter Kulesza and R. Douglas Watson, Dept. of Biology, University of Alabama at Birmingham, Birmingham, AL 35294.

The prothoracic glands of the tobacco hornworm, Manduca sexta, have been an advantageous model for investigating the mechanisms accompanying hormone-stimulated ecdysteroid secretion in insects. The mechanism that underlies the stimulation of ecdysteroidogenesis by 27 kDa prothoracicotropic hormone (big PTTH) is thought to involve a calcium-dependent increase in cAMP synthesis, activation of cAMP-dependent protein kinase, and protein phosphorylation. In this study we investigated the effects of big PTTH on protein biosynthesis. Prothoracic glands were incubated in vitro for 3 hours at 26°C in Grace's medium containing 35S-methionine (0.02 uCi/ul). Following the incubation, the glands were removed, rinsed, and homogenized. The medium was pooled, centrifuged, and the supernatant subjected to precipitation. Samples of gland homogenates were separated by SDS-PAGE, silver stained, and subjected to autoradiography. The specific activity of homogenate samples was determined by scintillation counting. The specific activity of gland samples that were stimulated with big PTTH was increased 1.8-fold over unstimulated controls, which is suggestive of an increase in protein biosynthesis. Interestingly, there were proteins found in the medium, and the amount released was increased under PTTH stimulation. This effect was evoked by big PTTH since lactate dehydrogenase assays suggest that 99.5% of cells were intact at the end of incubation.

ISOZYME PATTERNS IN CAHABA LILIES (HYMENOCALLIS CORONARIA)  
Ronald M. White, Jr., Christina Gargiulo, Scott Settle,  
Dr. Ronald L. Jenkins, and Dr. L. J. Davenport, Department of  
Biology, Samford University, 800 Lakeshore Drive, Birmingham,  
Alabama 35229.

Hymenocallis coronaria is an emergent aquatic plant that grows in the shoals of the major river systems of Alabama, Georgia and South Carolina. Seeds were gathered from 14 populations representing 10 river systems; hypocotyl material was examined for isozyme variations. Isozymes of alcohol dehydrogenase (ADH), aspartate aminotransferase (AAT), and glucose phosphate isomerase (GPI) were resolved on 12% starch gels in boric acid/lithium buffers at pH 8.3; isozymes of malate dehydrogenase (MDH), isocitrate dehydrogenase (ICDH) and acid phosphatase (AP) were separated on 2% agarose at pH 7.0 in histidine/citrate buffers. No variations in GPI, ADH, and AAT were detected from the 14 populations. There were numerous (5 to 7) isoforms of MDH, ICDH and AP, capable of distinguishing both distant and neighboring populations.

## Abstracts

AN ELECTROPHORETIC METHOD WHICH DETECTS EARLY BP VIRUS INFECTION IN SINGLE PROTOZOEAL OF Penaeus vannamei. George B. Cline and Kenneth C. Stuck, Biology Dept., UAB, Birmingham, AL 35294.

Penaeid shrimp aquaculture can be tragically affected by a variety of infectious agents including BP virus (baculovirus penaeus). Early larval stages are most susceptible to infection with development being slowed or arrested and 100% mortality in a matter of days. Although histological techniques can verify infection, it takes several days before diagnostic viral components are visible. Taking a different approach, we used our previously developed small sample electrophoresis technique to examine individual P. vannamei larvae from one hatch split into control and experimental groups. Both groups were fed rotifers at the protozoal-III stage but the experimental group's rotifers contained an infectious dose of BP virus. Larvae from each group were prepared for isoelectric focusing in thin layer pH 4-7 Immobiline gels, 30 min. and at 2, 6, 12, 18, 24, 48, 72, 96 and 120 hours after infection. Between 6 and 12 hours, several proteins near pH 5.1 disappear in infected larvae. By 18 hours new protein bands with isoelectric points (pI's) between pH 4.7 to 4.9 appear. Later (48 hours) additional new proteins appear between pH 4.2 and 4.3. Our technique corroborates evidence of early ultra-structural changes described by others. However, our ability to rapidly assess many single larvae in parallel provides a quick way to assess the extent and progress of BP virus infection in larval cultures of penaeid shrimp.

TYROSINASE ACTIVITY IN WILD-TYPE AND HYPERMELANISTIC MOSQUITOFISH (GAMBUSIA HOLBROOKI). Bart L. Scott and Robert A. Angus, Department of Biology, Univ. of AL at Birmingham, Birmingham, AL 35294

Some males of the eastern mosquitofish exhibit melanistic spotting due to large dermal macromelanophores. The gene for spotting is carried on the Y chromosome and shows temperature sensitive expression with the highest penetrance at cool temperatures (22°C) and the lowest penetrance at warm temperatures (28°C). Other vertebrates, such as the Siamese cat and the Himalayan rabbit, have temperature sensitive pigment alleles with maximal expression at cool temperatures. Previous studies with mammals indicate that their tyrosinase enzyme may not be maximally functional at body (=warm) temperature, possibly due to an inhibitor that binds more effectively to tyrosinase at warmer temperatures. I have been using a radiometric assay of tyrosinase activity to investigate whether temperature has the same effect on melanin synthesis in the eastern mosquitofish. Tyrosinase activity was compared in wild-type and spotted males at 22, 25, and 28°C. Results clearly show that, unlike the mammalian "Himalayan" allele, tyrosinase activity in spotted mosquitofish is greatest at warm temperatures.



## Abstracts

THE EFFECT OF SALINITY ON NA,K-ATPASE ACTIVITY IN THE BRINE SHRIMP ARTEMIA: POTENTIAL REGULATORY ROLE OF POLYAMINES. Kara Lee and Stephen A. Watts, Dept. of Biology, Univ. of Ala. at Birmingham, Birmingham, AL 35294.

The activity of ouabain-sensitive Na,K-ATPase was determined in partially purified membrane preparations. Enzyme activity was measured in stage I nauplii reared from cysts in either 6, 12, or 50 ppt seawater and assayed under varying Na<sup>+</sup>/K<sup>+</sup> concentrations. Activity was highest in individuals reared in 50 ppt seawater regardless of the assay conditions. Na<sup>+</sup> and K<sup>+</sup> concentrations of 100 and 25 mM, respectively, yielded maximal activity, and may reflect physiological levels in the organism. In Artemia reared in either 12 or 50 ppt seawater, a time course of enzyme activity was determined from the emergent stage (14 hr) through the mid-stage I nauplius larvae (26 hr). Increases in activity were seen with development for both groups of animals, however by 26 hrs activity in animals exposed to 50 ppt was significantly higher than in 12 ppt. The higher activity in animals acclimated at 50 ppt may be associated with the mechanism(s) for water and ion balance in hypoosmotic regulators. Na, K-ATPase activity in stage I nauplii reared in 50 ppt seawater was also determined in the presence of either 1, 2, or 4 mM concentrations of polyamines. Polyamines were inhibitory at all concentrations, with spermine exhibiting a 20% inhibition of enzyme activity. These results suggest a possible role for the polyamines in the short-term regulation of the Na,K-ATPase enzyme for regulation of salt transport.

ESTRADIOL AND PROGESTERONE IN THE GONADS OF THE TROPICAL SEA URCHIN EUCIDARIS TRIBULOIDES, Gene A. Hines, James B. McClintock and Stephen A. Watts, Dept. of Biology, Univ. of Alabama at Birmingham, Birmingham, AL 35294.

Individuals of the tropical sea urchin Eucidaris tribuloides were maintained under four different photoperiodic regimes (fixed long day, 15L:9D; fixed short day, 9L:15D; variable, in-phase with field populations; variable, six months out-of-phase with field populations) at 22°C, 32 ppt salinity and fed ad libitum nutrient agar blocks for one year. Samples of testes and ovaries were collected every three months and steroid levels were measured via RIA, yielding the first report of steroid levels in any echinoid species. Progesterone and estradiol were detected in the testes and ovaries of individuals exposed to either fixed or variable photoperiods. Throughout the study, progesterone levels ranged from 230-660 and 650-1090 pg/g in the testes and ovaries, respectively, with no apparent photoperiodic influence. Estradiol levels ranged from 0-433 and 15-533 pg/g in testes and ovaries, and decreased over time regardless of photoperiodic exposure. Previous studies have suggested that the environment, the endocrine system and the reproductive state of asteroids are linked. However, different photoperiodic conditions have generally similar effects on steroid levels in E. tribuloides, therefore the influence of photoperiod on steroids remains obscure.

**EMBRYO MICRO-MANIPULATION: THE DEVELOPMENT OF DEMI-EMBRYOS TO THE COMPACT MORULA OR BLASTOCYST STAGE.** Jacqueline U. Johnson, Dept. of Food Science and Animal Industries, Alabama A & M Univ., Normal, AL 35762. Adriel D. Johnson, Dept. of Biological Sciences, Univ. of Alabama, Huntsville, AL 35899.

This work was an initial step for the development of an embryo micro-manipulation and cryopreservation system for selected domestic animal species. A study was conducted to examine viability characteristics and transfer techniques of demi-embryos obtained from mice. In experiment one, developing embryos (4-8 cell stage) were collected by flushing the oviducts and uteri of superovulated donors, bisected, and cultured to the morula or the blastocyst stages. Of the demi-embryos cultured, 41% developed into the morula or blastocyst stages and 80% of the undivided zona-free (control) embryos developed into the morula or blastocyst stages. In experiment two, cultured demi-embryos were transferred to the uterus of a pseudopregnant recipient. The survival rate for the demi-embryos was 60%. The successful development and survival of bisected embryos could double the number of potential offspring from embryos recovered from donor females and subsequently transferred to recipient females. Further studies using these micro-manipulation techniques are needed for specific domestic animal species, to determine if similar survival rates can be achieved for the development of an embryo cryopreservation system.

**ISOZYMES OF TYROSINASE IN SAILFIN MOLLIES (*POECILIA LATIPINNA*).** Cynthia L. Blocker and Robert A. Angus Department of Biology, Univ. of AL at Birmingham, Birmingham, AL 35294

Tyrosinase, monophenol monooxygenase, is the necessary enzyme responsible for the synthesis of melanin pigment from the amino acid tyrosine. Tyrosinases have been described in mammals, lower animals, plants, and fungi. These various tyrosinases may differ in subunit compositions, molecular weight, isoelectric point, and amino acid composition. As many as four isozymes have been identified in mammals based on relative electrophoretic mobilities in polyacrylamide gel electrophoresis. The only study to investigate isozymes of tyrosinase in fish identified three forms in *Fundulus*. It is believed that these isozymes are produced through post-translational modification of a single unique polypeptide. Ongoing tyrosinase research in our laboratory employs a strain of sailfin mollies with a single mutant allele of tyrosinase that causes hypermelanistic pigmentation. We are using electrophoretic methods in attempt to determine the number of isozymic forms of tyrosinase in these and wild-type mollies.



## Abstracts

### DEVELOPMENTAL CHANGES IN THE PROTEIN CONTENT OF INSECT (MANDUCA SEXTA) PROTHORACIC GLANDS: RELATION TO ECDYSTEROID BIOSYNTHESIS.

Chi-Ying Lee, Phillip H. Chumley, and R. Douglas Watson, Dept. of Biology, University of Alabama at Birmingham, Birmingham, AL 35294.

In developing insects, cycles of growth and molting are controlled by steroid hormones termed ecdysteroids. During the last larval stadium of the tobacco hornworm, Manduca sexta, there occur developmental fluctuations in the capacity of prothoracic (molting) glands to synthesize and secrete ecdysteroids. Early in the stadium (days 0-2) the basal rate of in vitro secretion is low and the response to big prothoracicotropic hormone (big PTTH) is minimal. By about day 3, the basal rate of secretion has significantly increased, and the glands are fully competent to respond to big PTTH. In the present study we have investigated the relationship between steroidogenic competence and glandular proteins. Total glandular protein content (determined by the Bradford method) increased from  $1.20 \pm 0.35$  ug/gland on day 1 to  $12.32 \pm 1.90$  ug/gland on day 4, then remained at approximately that same level through day 10 (the day of pupation). Protein content was correlated with in vitro ecdysteroid secretion by unstimulated and PTTH-stimulated prothoracic glands. Glandular proteins were separated by SDS-PAGE (5-20% linear gradient according to the method of Laemmli). Preliminary densitometric analysis of silver-stained gels suggests that there are qualitative differences in proteins between glands of different developmental stages. Therefore, developmental changes in the steroidogenic competence of prothoracic glands appear to be associated with quantitative and qualitative changes in glandular proteins.

### ROLES OF CYCLIC AMP IN SMALL PROTHORACICOTROPIC HORMONE-STIMULATED ECDYSTEROID BIOSYNTHESIS. R. Douglas Watson and W. Eddie Yeh, Dept. of Biology, University of Alabama at Birmingham, Birmingham, AL 35294.

Insect prothoracic glands secrete steroid hormones (ecdysteroids) that drive insect development. In the tobacco hornworm, Manduca sexta, prothoracic glands are controlled by a set of bioregulatory molecules, including a pair of cerebral neuropeptides, big prothoracicotropic hormone (big PTTH) and small prothoracicotropic hormone (small PTTH). We are investigating the cellular mechanism of action of small PTTH. Results are consistent with the hypothesis that small PTTH stimulates steroidogenesis via a cAMP second messenger. (1) Treatment of glands with cAMP analogs resulted in a dose-dependent stimulation of hormone biosynthesis. (2) Intracellular levels of cAMP were elevated within two minutes of treatment with small PTTH; ecdysteroid synthesis was stimulated after a time lag of twenty minutes. (3) The effects of small PTTH on cAMP accumulation and ecdysteroid synthesis showed similar dose-dependency. (4) Treatment of glands with a cAMP antagonist (Rp-cAMPS) partially inhibited small PTTH-stimulated increases in steroidogenesis. Results conform to accepted criteria for identification of hormone second messengers.

THE PALEZONE SHINER, NOTROPIS sp. cf. PROCNE: REQUIEM OR RECOVERY? Melvin L. Warren, Jr. and Brooks M. Burr, Department of Zoology, Southern Illinois University, Carbondale, IL 62901.

The taxonomically undescribed palezone shiner, Notropis sp. cf. procne, has been known to ichthyologists for decades, but little in the way of documentation has been forthcoming on its national conservation status. It differs morphologically from the swallowtail shiner, Notropis procne, a species restricted principally to Atlantic Slope drainages, by having a more slender and cylindrical body shape, a pigmentless stripe above a black midlateral stripe, usually 36 to 38 lateral line scales, and in details of tuberculation. The species is known presently to occur in the Little South Fork of the Cumberland River (LSFCR), Kentucky; the Paint Rock River (PRR), Alabama; and historically from Marrowbone Creek (last collected in 1947), Kentucky and Cove Creek, Tennessee (last collected in 1936). It is most abundant in a six-mile reach of the LSFCR from about the mouth of Corder Creek downstream to Freedom Church Ford; it appears less common and more sporadic in occurrence in about 15 river miles of the PRR between Princeton and Estill Fork. The palezone shiner shows an affinity for flowing pools and runs of upland streams that have permanent flow; clean, clear water; and substrates of bedrock, cobble, pebble, and gravel mixed with clean sand. As judged from recent collecting efforts and known post-1960 distribution, it is clear that the species now is restricted to two small river systems, LSFCR and PRR. Both of these represent remnants of lotic systems that at least until recently retained physical and biotic characteristics exemplary of the pre-historical norm. Various threats (e.g., toxic mine discharge, poor land-use practices, reservoir construction, channelization, inadequate instream flow) jeopardize the continued existence of this fish. We are in the process of taxonomically describing the palezone shiner and clarifying its relationship to N. procne, and recommend that it be considered a nationally threatened, possibly endangered, species.

DRYOPTERIS LUDOVICIANA (KUNZE) SMALL: ITS DISTRIBUTION AND STATUS IN ALABAMA. Eddie Watkins, Carroll High School, Ozark, AL and Alvin R. Diamond, Jr., Troy State University Arboretum, Troy, AL.

The uncommon southern woodfern Dryopteris ludoviciana appears to have no imminent threats to its continued existence in Alabama. It is currently known from Conecuh County (7 populations), Crenshaw County (3 populations), Dale County (1 population), Henry County (1 population) and Houston County (2 populations). Most populations occur where limestone is at or near the surface, and plants are often epipetric. Population size ranges from less than 50 to more than 1,000 individuals. An additional 2 populations known from herbarium records 1 each in Conecuh and Houston County were not relocated and are presumed destroyed. Extensive field surveys of South Alabama as well as herbarium surveys failed to reveal any additional populations.



**DOCUMENTED OCCURRENCES OF *FELIS CONCOLOR* IN ALABAMA.**

Mark A. Bailey, Alabama Natural Heritage Program, ADCNR State Lands Division, 64 North Union Street, Montgomery, AL 36130.

The Florida panther (*Felis concolor coryi* Bangs), and possibly the eastern cougar (*F. c. cougar* Kerr) historically occurred in Alabama, but due to the complete lack of museum specimens from the state, historic ranges of subspecies are problematic. Bartram wrote of "tygers" (presumably panthers) on the lower Tombigbee River in 1791. Arthur H. Howell (1921) summarized reports from various sources, including two 1820 reports by A. Hodgson of an animal killed on "Ouchee Creek" (Lee or Russell counties) and a mounted specimen near Blakeley, Baldwin County. Howell stated that "recent reports indicate that a very few may still remain in the big swamps of the southern counties". Although virtually extirpated today, the species has been reliably reported killed or captured in Alabama at least three times in the past 43 years. Department of Conservation and Natural Resources personnel or publications reported the presence of *Felis concolor* in Alabama six times during this period. Reports include: St. Clair County (1948), Dale and Washington counties (1956), Clarke County (1961 and 1966), Baldwin County (1974), and Greene County (no date). An additional literature report documents one animal shot in Tuscaloosa County in 1956. A recent (August, 1990) videotape, in the possession of the Department of Conservation, of a free-roaming individual near the Alabama River in Autauga County, along with the frequency and nature of unconfirmed reports from densely forested and remote areas along the Tombigbee and Alabama rivers in southwest Alabama, suggest that a few *Felis concolor* may still remain in the state. Whether these individuals represent a native population or are escaped captives is unknown, but the 1974 report of a pair with cubs in northern Baldwin County suggests these, at least, were the former.

**ASPIRIN TOTALLY BLOCKS 5-AZACYTIDINE-INDUCED CHANGES IN HEMOGLOBIN PROPORTIONS IN ADULT RATS.** Veronica D. Boswell and Mukul C. Datta, Dept. of Chemistry, Tuskegee University, Tuskegee, AL 36088.

In recent years, 5-azacytidine (AZA) has been shown to induce fetal hemoglobin (HbF) synthesis in adult humans and primates. We administered AZA in adult rats, in an attempt to study its mechanism of action on the switching of adult Hb proportions toward newborn proportions. Sprague-Dawley or Wistar or Long-Evans rats were used in this study. Hb components were separated by ion-exchange chromatography from blood samples drawn once a week (always Friday) for seven weeks in a row. AZA was able to induce newborn like Hb proportions significantly for all the strains studied. However, the switching effect of AZA was totally lost if aspirin (20 mg/day/500 gm body weight) was simultaneously administered into the rats. Aspirin alone had no effect on the Hb components in normal control rats. Our results thus reveal the importance of concurrent prostaglandin synthesis as a required ongoing process for the expression of AZA-mediated changes in Hb proportions of adult rats. Knowledge of control mechanisms affecting the proportions of major and minor hemoglobins in rats should be useful in designing future treatments for pharmacologic manipulation of HbF synthesis for diseases such as sickle cell anemia and thalassemia.

THE EFFECTS OF SALINITY ON EMBRYOGENESIS, JUVENILE AND ADULT GROWTH AND EGG MASS DEPOSITION IN THE GASTROPOD PHYSELLA CUBENSIS. Donald L. Thomas, James B. McClintock, Eugenia Williams and Melinda McMorris. Dept. of Biology, Univ. of Alabama at Birmingham, AL 35294.

Embryonic, juvenile and adult Physella cubensis were raised in various salinity treatments in the laboratory and mortality, growth, feeding and egg mass deposition documented. Embryonic P. cubensis did not survive in salinities greater than 0.5 ppt. Embryos held at 0.5 ppt ceased development after attaining the blastula stage. Juveniles also did not survive at salinities greater than 0.5 ppt. Juveniles raised in freshwater and at 0.5 ppt salinity attained similar mean shell lengths (2.5 mm) over a 21 day period. Adults did not survive salinities greater than 2.5 ppt. longer than 9 days. Feeding rates were highest in freshwater and at 2.5 ppt, while individuals at 6.0 ppt salinity ceased feeding. No egg masses were produced under any of the salinity treatments. Although adult snails can function at low salinities (2.5 ppt), they do not produce egg masses. Moreover, embryos exposed to even very low salinity (0.5 ppt) do not survive. These data suggest that salt water effluents pumped into freshwater habitats could significantly impact populations of P. cubensis.

BIOMASS ALLOCATION IN CARNIVOROUS AND NON-CARNIVOROUS BOG PLANTS IN THE CENTRAL GULF AREA. Debbie A. Damerow and George W. Folkerts, Dept. of Zoology, Auburn University.

Carnivorous plants acquire their nutrients through the digestion of small animals. These plants inhabit acidic, mineral-deficient bog sites where a number of non-carnivorous species also exist. It is hypothesized that, because of the importance of prey capture by the leaves, carnivorous plants would expend more energy and materials in producing the above ground portion of the plant than they would in producing the root system. Conversely, non-carnivorous species might be expected to produce large root systems to gather the sparse soil nutrients. Shoot/root and above ground/below ground biomass data was obtained on three carnivorous (Drosera capillaris, Sarracenia leucophylla, Sarracenia psittacina) and four non-carnivorous species (Chaptalia tomentosa, Chondrophora nudata, Eryngium integrifolium, Lobelia amoena) occupying bogs in the central Gulf Coast area. The dry weights of ten specimens of each of the species were obtained. Preliminary results indicate that there are no significant differences in biomass allocation patterns between carnivorous and non-carnivorous species.



**EFFECTS OF MICROGRAVITY ON PANCREATIC CELLS.** Rebecca Conway, Adriel D. Johnson, and Marian L. Lewis, Dept. of Biological Sciences, Univ. of Alabama, Huntsville, AL 35899.

This was the first known study conducted to characterize the effects of altered gravity on chick embryonic pancreatic fragments. Pancreatic fragments from 18d chick embryos were cultured 72hr in a rotating culture system (RCS), which has been shown to produce similar physiological effects seen in microgravity. Culture media was removed at 0hr, 24hr, 48hr, and 72hr and evaluated for metabolic parameters and enzyme release. Histological examination revealed viable tissue at the end of the 72hr (RCS) incubation period. Initial media glucose levels were 112mg/dl and decreased to 55mg/dl over the incubation period. Media amylase measured ranged from 0 to 721U/L over the 72hr incubation period. Metabolic parameters of initial media CO<sub>2</sub> increased 76% whereas oxygen levels decreased. This study showed that pancreatic tissue can maintain metabolic and physiological functions in culture and that further studies are needed to determine changes of other pancreatic functions in microgravity environments.

**INHIBITION OF ORNITHINE DECARBOXYLASE IN BRINE SHRIMP: IMPLICATIONS DURING OSMOTIC STRESS.** Stephen A. Watts and Edward Yeh, Dept. of Biology, UAB, Birmingham, AL 35294. Raymond Henry and Christine Sundermann, Dept. of Zoology, Auburn Univ., Auburn, AL 36849.

Stage I (24 hr) nauplii of the brine shrimp Artemia were incubated in the presence of the suicide inhibitor  $\alpha$ -difluoromethyl-ornithine (DFMO), specific to ornithine decarboxylase (ODC). In 24 hr nauplii reared in 50 ppt seawater, exposure to control (50 ppt) or hypoosmotic conditions (10 ppt) in the presence or absence of DFMO (1 mM) resulted in increased hydration in individuals exposed to 10 ppt and 10 ppt + DFMO. In addition, a significant increase in hydration in individuals exposed to 50 ppt + DFMO was observed, suggesting a possible interaction of polyamine metabolism and ion transport. Toxicity assays indicated that DFMO showed a dose dependent effect on mortality with highest mortality (100%) at 10 mM occurring within 24 hrs, decreasing to <10% at 1 mM. However these results may be confounded by the effects of decreased pH observed during incubation. After 5 hours of incubation of nauplii in 10 mM DFMO, endogenous ODC levels decreased by 70% when compared to controls, however polyamine levels remained stable, and minor increases in putrescine and decreases in spermidine were found. After 11 hrs of incubation, ODC activity was 50% higher than controls. ODC activity decreased in the presence of 0.5 mM putrescine, regardless of DFMO treatment. These data suggest that complex interactions exist among hypoosmotic stress, ODC production and polyamine synthesis, and require further study.



## Abstracts

THE RELATIONSHIP OF AGE, SEX AND PREGNANCY ON PLASMA GLUCOSE LEVELS IN GUINEA PIGS. Larry R. Boots. University of Alabama at Birmingham, UAB Station, Birmingham, AL 35294.

The purpose of this study was to obtain baseline data in an effort to develop the guinea pig as a model for the study of regulation of glucose metabolism by vitamin B<sub>6</sub> and its metabolites. Blood samples were obtained beginning at about one month of age in 20 females, 12 males and during 12 pregnancies in 8 other females. Body weight was recorded at each sampling and glucose levels determined. Mean glucose levels for female, male and pregnant animals were, respectively, 156.1, 222.4 and 121.9 mg%. Glucose levels compared to body weight groups were as follows for nonpregnant females: < 300 gm, 102.0 mg%; 300-399 gm, 114.6 mg%; 400-499 gm, 109.1 mg%; 500-599 gm, 118.1 mg%; 600-699 gm, 128.6 mg%; 700-799 gm, 157.8 mg%; 800-899 gm, 160.6 mg%; 900-999 gm, 190.1 mg% and >1000 gm, 197.7 mg%. For males in the same weight groupings, glucose levels were 102.7, 112.3, 99.0, 169.9, 112.4, 147.7, 157.9, 185.6 and 272.4 mg%, respectively. When nonpregnant females were grouped by age, the glucose levels were: <50 days, 104.2 mg%; 50-99 days, 122.0 mg%; 100-149 days, 146.3 mg%; 150-199 days, 172.6 mg%; 200-249 days, 158.1 mg%; 250-299 days, 141.5 mg%; 300-349 days, 155.0 mg%; 350-399 days, 177.8 mg%; 400-449 days, 181.1 mg% and >450 days, 155.1 mg%. For males in the same age groupings, glucose levels were 107.4, 103.2, 164.3, 238.2, 182.4, 153.0, 170.8 181.0 and 185.5 mg% (no group >450 days). No correlation was observed between glucose levels and length of gestation.

VERIFICATION OF A ZONA BINDING SITE ON MURINE SPERM USING ANTI-ZONA ANTIBODIES. Holly L. Boettger-Tong, D.J. Aarons, and G.R. Poirier, Dept. of Biology, Univ. of Ala. at Birmingham, Birmingham, AL 35294.

Species-specific fertilization is ensured via many adaptive mechanisms. At the cellular level, interacting substances on the surfaces of gametes permit the recognition and binding of sperm to egg. Considerable success has been achieved in the identification of sperm binding sites on the egg; however, less information is known about the zona binding site on sperm. To localize the domain on the sperm head to which zona proteins bind, polyclonal antibodies have been developed against the two zona pellucida glycoproteins (ZP2 and ZP3) directly involved in sperm binding. The specificity of these polyclonal antibodies has been tested using a number of techniques, including indirect immunofluorescence and Western blotting. Preliminary evidence indicates that the antibody to ZP3 localizes solubilized zona pellucida glycoproteins bound to capacitated murine sperm. Using the indirect immunofluorescence technique, ZP3 was localized in a wedge-shaped pattern, in an area corresponding to the acrosomal cap and equatorial regions of the murine sperm head. When the immune serum was omitted or when anti-ZP2 or normal rabbit serum was substituted for anti-ZP3, few sperm demonstrated this pattern. This data suggests that sperm receptors for ZP3 lie in the acrosomal cap and equatorial region of the sperm head.

## Abstracts

PRELIMINARY STUDIES ON ASPECTS OF THE FORAGING ECOLOGY OF *ASTROPECTEN ARTICULATUS* (ASTEROIDEA: ECHINODERMATA) FROM THE NORTHERN GULF OF MEXICO. Steven D. Beddingfield, James B. McClintock and Ken Marion, Dept. of Biology, Univ. of Alabama at Birmingham, and T. S. Hopkins, The Univ. of Alabama at Birmingham, Birmingham, AL 35294, and The Marine Environmental Science Consortium, Dauphin Island, Alabama 36528.

Prey items of *Astropecten articulatus* were investigated by examining the stomach contents of individuals collected by trawl from the northern Gulf of Mexico. Cumaceans, bivalves, mysids and gastropods were the most abundant prey species represented. The mean size of prey was 4.0 mm, ranging from 0.2 to 14.0 mm. Each sea star contained approximately 6 identifiable prey taxa in addition to detrital material. Prey size selectivity was investigated in the laboratory by presenting individuals ( $x \pm R = 49$  mm) with three sizes (0.5, 1.0, 1.5 cm diameter) of circular food models composed of a mixture of 5% fish meal in Plaster of Paris. Individuals presented with equal amounts of food models (ie. 20 small, 10 medium and 5 large) showed a significant preference for the smallest sized prey. No large models were ingested. Individuals offered equal numbers of different sized prey models also demonstrated a preference for smaller sized food models, but ingested larger numbers of medium sized models. Sea stars presented only large sized prey ingested these food models, indicating an ability to handle larger prey. Average handling times for small, medium and large sized models were 1.8, 6.0, and 10.7 min, respectively. Size selective feeding may be attributed to the ease of manipulation of smaller sized prey, which maximizes food intake per unit time. Mechanical constraints associated with morphological characteristics of mouth parts may determine the maximal sized prey which can be ingested. Supported by EPSCoR NSF grant #R11-8996152.

SOME ASPECTS OF THE FLORA OF RANDOLPH COUNTY, ALABAMA. Christopher F. Nixon, Anniston Museum of Natural History, Anniston, AL 36202. R. David Whetstone, Department of Biology, Jacksonville State University, Jacksonville, AL 36265.

A Flora was undertaken to document the vascular plant taxa found within the Piedmont of Alabama. A total of 881 specific and infra-specific taxa are documented, an increase of 683 taxa being added to the previous literature records for the county. The work includes scientific and vernacular names, an analysis of life-forms, duration, diaspore types, flowering and fruiting phenology, habitat and distribution types. Endangered, threatened, and rare species are discussed, along with a listing of those taxa believed to have recently disappeared from the flora.



## Abstracts

ENERGY METABOLISM OF *MYTILUS EDULIS* GILLS UNDER VARYING CONDITIONS OF ENERGY SUPPLY AND DEMAND. Jeannette E. Doeller, David W. Kraus, Dept. Biology, Univ. Alabama at Birmingham, 35294; Erich Gnaiger, Institute for Zoology, Univ. Innsbruck, Austria; and J. Malcolm Shick, Univ. Maine, Orono, 04469.

The gill of bivalve molluscs is situated at an interface between animal and environment. As a result, the gill is exposed to a variety of environmental conditions. In the gill, cilia propel a flow of water past the gills to deliver oxygen and nutrition to the animal. Ciliary activity, driven by dynein ATPases, requires a continual supply of ATP at a rate sufficient to match the rate of ATP hydrolysis. Control of the balance between ATP supply and demand in the ciliated bivalve gill, and how this balance may be altered by environmental stresses, is unknown. In this pilot study, metabolic flux was examined using excised gills from the marine mussel *Mytilus edulis*. The energetic state of the gills was manipulated by increasing energy demand (increasing ciliary beat frequency with serotonin) and decreasing energy supply (limiting respiration with low pO<sub>2</sub>). Heat and oxygen flux were measured simultaneously with calorimetry. In parallel, metabolic state was monitored by recording the redox state of mitochondrial cytochromes with *in vivo* spectrophotometry. For each experiment, one excised demibranch was supported by a custom-designed gill holder so as not to interrupt water flow by lateral and frontal cilia or diffusion distances to the ciliated epithelial cells. At pO<sub>2</sub> above 30 torr, heat flux was supported by aerobic metabolism. Anoxic heat flux was less than 2% of aerobic heat flux, indicating very little anaerobic capacity. Heat and oxygen flux nearly doubled in gills with increased ciliary beat frequency; however, half-maximal pO<sub>2</sub> for metabolic rate and reduction of mitochondrial cytochromes remained unchanged. These data indicate that limitation to oxygen diffusion imposed by boundary layers may be reduced when ciliary beat frequency is elevated; thus, oxygen flux to intracellular mitochondria is enhanced and matches the increased oxygen demand by the cilia. Supported in part by Fulbright Fellowship to JED, NSF Biological Instrumentation grant BBS-8716161 to JMS, and FFF Austria project Nr. 2/270 to Cyclobios.

UNITED NATIONS VOTING AND UNITED STATES FOREIGN AID TO LATIN AMERICA FROM 1966 TO 1985. Joseph Strength, Undergraduate, Univ. of Ala., Tuscaloosa, AL 35486. Colby Allsbrook, Undergraduate, Univ. of Ala., Tuscaloosa, AL 35486. Dr. Gerald Webster, Dept. of Geography, Univ. of Ala., Tuscaloosa, AL 35486.

Does United States foreign aid influence voting in the United Nations' General Assembly? This study examines the relationship between U.S. foreign aid and the General Assembly votes of Latin American and Caribbean states for the period from 1966 to 1985. Using correlation analysis, this study tests the hypothesis that aid is used as an inducement for voting support for the U.S. position by twenty-three countries. The results of this cross-sectional analysis provide a moderate level of support for this hypothesis, particularly in the latter years of the study.



**PHYSIOLOGICAL EFFECTS OF HYDROGEN SULFIDE ON BIVALVE MOLLUSCS.**  
David W. Kraus and J. E. Doeller, Dept. Biology, Univ. Alabama at Birmingham, 35294.

Bivalve molluscs are found in habitats ranging from those with hard substrate, high oxygen and no sulfide to those with soft sediment, low oxygen and high sulfide. To survive in habitats with high sulfide, bivalves either have mechanisms that detoxify sulfide or they avoid the toxic effects of sulfide. Bivalve gills, an important interface between animal and environment, are an initial site of sulfide exposure and thus may exhibit adaptations that mitigate the effects of sulfide. Gills of the blue mussel *Mytilus edulis* from rocky intertidal shores were compared to gills of the ribbed mussel *Geukensia demissa* from muds of *Spartina* grass beds in terms of their response to sulfide exposure. When exposed to 300  $\mu$ M sulfide, the oxygen consumption rate of *M. edulis* gills declines to about 25% of their rate in sulfide-free seawater, whereas the oxygen consumption rate of *G. demissa* gills increases to more than 200%. These data suggest that sulfide enters the gills of both mussels and inhibits oxygen uptake in *M. edulis*, probably by blocking mitochondrial cytochrome oxidase function, whereas it stimulates oxygen uptake in *G. demissa*, possibly for sulfide oxidization. The oxygen uptake rate of *M. edulis* gills was also more sensitive to cyanide, which may indicate that their cytochrome oxidase has a higher affinity for ferric ligands such as cyanide and sulfide. Spectrophotometric measurements of the oxidation/reduction state of mitochondrial cytochromes in intact living gills support these results. The partial pressure of hydrogen sulfide causing 50% reduction of mitochondrial cytochromes was about 0.2 torr in *M. edulis* compared to 2 torr in *G. demissa*, again indicating that cytochromes of *M. edulis* are more sensitive to sulfide. An extreme adaptation to habitats with high sulfide is the incorporation of sulfide-oxidizing chemoautotrophic bacteria as symbionts into specialized gill cells called bacteriocytes. *Solemya reidi*, a symbiont-containing bivalve, inhabits sulfide-rich sediments. Sulfide exposure of isolated gills, up to 7 torr, causes the reduction of a single cytochrome c which may be associated with bacterial sulfide oxidation. Evidence of reduction of mitochondrial cytochromes is absent in the bacteriocyte domain, and may be avoided by symbiotic oxidation of sulfide.

**SOILBORNE WHEAT MOSAIC VIRUS IN ALABAMA.** Ping Jin and Robert T. Gudauskas, Dept. of Plant Pathology, Auburn Univ., AL 36849.

Soilborne wheat mosaic virus (SBWMV) was found for the first time in Alabama in 1989 in a few fields in Autauga County. In 1990, the virus was diagnosed on wheat in Cherokee, Limestone, and Madison counties as well as in Autauga County. Typical symptoms on diseased wheat were mosaic patterns of elongate streaks or stripes of various shades of green and yellow on the foliage and mild to severe stunting of plants. Electron microscopy of crude dip preparations from symptomatic wheat leaves showed virus particles of two principal lengths, about 140 and 280 nm. Resting spores of the vector of SBWMV, the fungus *Polymyxa graminis*, were observed in the roots of SBWMV-infected wheat. Studies to determine the distribution and importance of SBWMV in Alabama and the susceptibility of wheat cultivars to the virus are currently in progress.

## Abstracts

Demonstration of insulin binding structures in Tetrahymena pyriformis.  
Gayle K. Christopher and C. Sundermann. Department of Zoology &  
Wildlife, Auburn University, AL 36849.

To determine if T. pyriformis possess binding structures for the vertebrate hormone insulin and if prior exposure to insulin increases hormone binding upon reexposure, cultures were first inoculated and allowed to reach logarithmic phase in Medium 357. The cells were then exposed (imprinted) to insulin at the concentrations of 0, 3, 6, and 12  $\mu\text{g/ml}$  for one hour. The cells were then washed and returned to plain medium. After a 24 hour post-imprint culture period the cells were fixed in 4% formalin, washed several times and then incubated with 0.2 mg/ml insulin in PBS. Following several washes the cells were dropped on slides and allowed to dry. Immunocytochemistry was accomplished using a primary antibody ( $\text{Ab}^1$ ) to porcine insulin and a secondary antibody kit. One slide from each imprint concentration was not exposed to  $\text{Ab}^1$ . Results indicate that T. pyriformis does bind insulin even in the control (no imprint) condition. Cilia were translucent in the slides not exposed to  $\text{Ab}^1$  but were obviously stained in all slides receiving  $\text{Ab}^1$ . Staining intensity increased at 6 and 12  $\mu\text{g/ml}$  imprint over the control ( $P < .01$ ) but was not different from control at 3  $\mu\text{g/ml}$  imprint level. Both the 12 and 6  $\mu\text{g/ml}$  imprinted cells stained more intensely than the 3  $\mu\text{g/ml}$  cells ( $P < .05$ ) but the higher imprint concentrations were not different from each other. The results confirm that T. pyriformis does bind insulin and that prior exposure to insulin increases the binding capacity for insulin. Furthermore, this positive imprint may be concentration dependent. Supported by NSF, DCB 8718174.

BEHAVIORAL REGULATION OF HEMOLYMPH OSMOLARITY THROUGH SELECTIVE DRINKING IN LAND CRABS, BIRGUS LATRO AND GECARCOIDEA LALANDII. Angela Boynton, C.A. Combs, N. Alford, M. Dvornak, and R.P. Henry. Auburn University.

Drinking behavior in B. latro and G. lalandii was monitored by videotape under controlled laboratory conditions. B. latro displayed the drinking behavior typically observed in nature (Lister 1888, Gross 1955). G. lalandii behaved similarly and, in addition, immersed themselves in water. Under normal conditions (blood osmolarity  $< 1000 \text{ mOsm}$ ) neither species appeared to show a preference for drinking fresh or saltwater. When desiccated (blood osmolarities  $> 1050 \text{ mOsm}$ ) B. latro altered its drinking behavior and showed a preference for freshwater. Preliminary results for G. lalandii indicate a similar response. This behavior, bouts of excessive polydipsia, led to a restoration of original hemolymph osmolarity values. Supported by NSF DCB 88-01926 to R.P.H.



SARCOPHAGID FLIES ASSOCIATED WITH PITCHER PLANTS (Sarracenia sp.) IN THE CENTRAL GULF REGION. Stephen P. Yanoviak and George W. Folkerts, Department of Entomology and Department of Zoology and Wildlife Science, Auburn University, AL 36849.

Species of two flesh fly (Diptera: Sarcophagidae) genera complete larval development within the mass of insect remains found inside the tubular leaves of pitcher plants (Sarracenia sp.). More than fifty flies were collected from various pitcher plant sites in coastal Mississippi, Alabama and the Florida panhandle. Adult flies were collected with a sweep net. Larvae were removed from pitchers of Sarracenia alata, S. leucophylla, S. flava, S. rubra ssp. wherryi, and S. purpurea. These were reared to adulthood in the laboratory using apparatus that mimicked conditions inside and outside the pitchers of Sarracenia sp. Sarraceniomyia sarraceniae (Riley) was the most abundant fly collected, followed by Fletcherimyia rileyi (Aldrich) and Fletcherimyia celarata (Aldrich). Up to four larvae were found to simultaneously inhabit a single pitcher. Fly larvae leave the pitchers and burrow to a depth of several centimeters in the surrounding soil to pupate. Larvae appear to overwinter in the soil. The length of the pupal stage is uncertain, but adult flies emerge approximately 25 days after larvae leave the pitchers and enter the soil. It is likely that all species may pass through several generations during a season. Evidence of host plant specificity was not detected among the flies collected.

EFFECT OF TIME, TEMPERATURE, AND BACTERIA ON THE PHAGOCYTIC RESPONSE OF OYSTER HEMOCYTES. Linda H. Hopkins, Jacksonville State Univ., Jacksonville, AL, Mark L. Tamplin, Univ. of FL, Gainesville, FL, and William S. Fisher, Univ. of TX, Galveston, TX.

To better understand the relationship between bacteria and oyster tissues, we examined the phagocytic response of oyster hemocytes to temperature, time, and bacteria (Vibrio species), including V. vulnificus, V. cholerae, and V. parahaemolyticus. Vibrio bacteria are believed to be natural flora of the Gulf Coast oyster, Crassostrea virginica, and have been associated with human disease following consumption of raw oysters. A fluorescent-staining technique was developed to visualize the phagocytic response. The results showed that the number of hemocytes binding bacteria increased with time, ratio, and temperature. However, the rate of phagocytosis was similar for all of the Vibrio species tested. Understanding these cellular interactions may explain how vibrios are retained in oyster tissues and their ecology in estuarine environments.



## Abstracts

ANALYSIS OF STICK INSECT VITELLOGENIN METABOLISM USING BREFELDIN A AND MONOCLONAL ANTIBODIES. B. H. Estridge and J. Bradley, Auburn University, AL, 36849; F. Giorgi, A. Cecchetti, and M. Masetti, University of Pisa, Italy.

Vitellogenin (VG), the hemolymph-borne precursor to egg vitellin (VN), is synthesized by insect fat body, secreted into the hemolymph, sequestered by vitellogenic oocytes via receptor-mediated endocytosis, and proteolytically processed during embryogenesis. In the parthenogenic stick insect, Carausius morosus, native VNs A and B are resolved by SDS-PAGE into polypeptide subunits A1, A2, and A3 and B1 and B2 respectively. The post-translational processing of VG/VN in fat body and oocytes was examined using radiolabeling, monoclonal antibodies (MAb), and electron microscopy. *In vivo* and *in vitro* labeling revealed that VG traverses the secretory pathway in one hour, that all polypeptide subunits except B2 are glycosylated before secretion into hemolymph and that all except B2 undergo a change in molecular weight upon transfer from fat body to hemolymph. MAb 1C3 is specific for A4, a polypeptide present in developing follicles but absent in hemolymph. MAb 1B12 is specific for A3, which is processed from a 60 kD to a 50 kD polypeptide late in follicle development. Experiments using brefeldin A (BFA) indicate that fat body secretion of VG decreases dramatically following *in vitro* exposure to BFA levels above 5 ug/ml and that this is accompanied by alterations in the ultrastructure of the Golgi complex in the fat body. Supported by Alabama NSF/EPSCoR Grant RII-8610669.

### **DISTRIBUTION, UPTAKE, AND RETENTION OF VIBRIO VULNIFICUS BY TISSUES OF THE EASTERN OYSTER, CRASSOSTREA VIRGINICA.**

Gesa M. Capers\* and Mark L. Tamplin. US FDA, Fishery Research Branch, Dauphin Island, Alabama and University of Florida, Gainesville, Florida.

Vibrio vulnificus is a frank human pathogen often associated with Crassostrea virginica. It was measured in individual tissues of freshly harvested oysters and in oysters subjected to depuration by ultraviolet light and filter-sterilized seawater. V. vulnificus was enumerated with the most probable number technique in homogenates of whole oyster tissues and in individual tissues, including the hemolymph, digestive region, gills, mantle, and adductor muscle. V. vulnificus was identified by enzyme immunoassay. In freshly harvested summer oysters, the digestive region contained the highest concentration of V. vulnificus, with decreasing numbers in the adductor muscle, mantle, gills, and hemolymph. Concentrations and distribution of V. vulnificus in oyster tissues differed for warmer and colder months. Depuration did not reduce V. vulnificus numbers in whole oysters, but changed their distribution in tissues. Specifically, V. vulnificus concentrations increased in the adductor muscle, mantle, and gills. The organism replicated in oyster tissues and was released at a rate of approximately 500 cells per oyster per hour per 100 ml seawater. In separate studies, V. vulnificus labeled with an antibiotic marker entered and was distributed in oyster tissues within 4 hours. These findings indicate that V. vulnificus is part of the microbial flora of oysters and that it replicates within oysters.

**TYROSINASE ACTIVITY IN SAILFIN MOLLIES (*POECILIA LATIPINNA*) HETEROZYGOUS FOR A TEMPERATURE-SENSITIVE HYPERMELANISM ALLELE.** Paul D. Blanchard and Robert A. Angus, Department of Biology, Univ. of AL at Birmingham, Birmingham, AL 35294

Melanophores, which are one of several types of pigment cells found in lower vertebrates, produce melanin pigment by catalyzing the oxidation of tyrosine with the enzyme tyrosinase. Two types of melanophores exist in poeciliid fishes: micromelanophores, which are relatively small and distributed rather uniformly over the body of the fish, and the much larger macromelanophores which, in sailfin mollies, occur in clusters to produce large black spots. The allele is expressed maximally at cool temperatures (~22°C) and fish raised at 22° develop both micro- and macromelanophores. When fish are raised at 28°C, the expressivity of the allele is much reduced and few macromelanophores are produced. This is at least superficially similar to the "Himalayan" allele in mammals where increased production of melanin at cool temperatures results from a heat-sensitive tyrosinase enzyme. We used a radiometric assay employing <sup>14</sup>C-labeled tyrosine to investigate tyrosinase activity in a strain of sailfin mollies heterozygous for the temperature-sensitive macromelanophore allele. Unlike the case in Himalayan mammals, tyrosinase activity did not correlate with expressivity of the macromelanophore allele. Tyrosinase activity was significantly higher at 28° than at 22°. Thus, production of macromelanophores is probably affected by a temperature-sensitive regulatory gene, not the structural gene for tyrosinase enzyme.

**A SHARP RISE IN THE NUMBER OF BOTTLENOSE DOLPHINS FOUND DEAD IN ALABAMA.** Gerald T. Regan, Department of Biology, Spring Hill College, Mobile, AL 36608.

Fifty-nine bottlenose dolphins (*Tursiops truncatus*) were found dead (stranded) in Alabama in 1990, almost five times more than in any of the three previous years (1989: 11; 1988: 12; 1987: estimated 12). As in the earlier years, strandings were concentrated in the March–April interval (1990: 37%; 1987–1989: 41%). There were 10 neonates (5 male, 3 female, 2 unknown) and 45 larger specimens (24 male, 17 female, 4 unknown). Four more were of uncertain size and sex. There was no evidence of violence or emaciation. Nematode lungworms were in 15.3% (9) in contrast to 6.8% of the 1987–1989 dolphins. There were shark bites on only 6.8% (4) as compared to 13.8% in 1987–1989. Among correlates of the increase in strandings were similar increases in other states of the northern Gulf, ice formation in some estuaries in late 1989, and a several thousand per cent increase in commercial shark landings in the northern Gulf.



## CHEMISTRY

SYNTHESIS OF 1-[2-(1-HYDROXY-1-PHENYL)ETHYL]-4-PROPANANILIDOPERHYDROAZEPINE: A POTENTIAL ANALGESIC. Shridhar V. Andurkar, J. DeRuiter, T. N. Riley and F. Taylor Noggle, Department of Pharmacal Sciences, School of Pharmacy, Auburn University and Alabama Department of Forensic Sciences, Auburn, Alabama 36849.

Earlier we reported the synthesis and analgesic activity of a number 1-substituted 4-(propananilido)perhydroazepines (4-PPAs). The impressive activity displayed by these compounds prompted the present to study to prepare additional 4-PPA analogues, such as 1-[2-(1-hydroxy)-1-phenyl]ethyl--4-PPA, and enhance the efficiency of the synthesis. The initial step of the synthesis involved ring expansion of 1-carbethoxy-4-piperidinone with ethyl diazoacetate and boron trifluoride to yield 1,5-biscarbethoxyperhydroazepin-4-one (BCPA). Selective ester hydrolysis of BCPA, followed by decarboxylation provided 1-carbethoxyperhydroazepin-4-one (CPA). Reductive amination of CPA with aniline afforded the 4-anilido intermediate and this was treated with propionic anhydride to give 1-carbethoxy 4-(propananilido)-perhydroazepine (CPPA). Selective cleavage of the 1-carbethoxy group of CPPA was then accomplished with trimethylsilyl iodide, and the intermediate 4-(propananilido)-perhydroazepine was treated with styrene oxide to yield the desired product, 1-[2-(1-hydroxy)-1-phenyl]ethyl]-4-perhydroazepine. This is an efficient and versatile synthesis which can be used to prepare various 1-substituted 4-PPA analogues.

MESOCYCLIC POLYTHIOETHERS AS PHARMACOLOGIC CHELATING AGENTS: SYNTHESIS, COMPLEXATION, AND TOXICITY STUDIES OF 1,4,7-TRITHIACYCLODECAN-9-OL AND 1,5,9-TRITHIACYCLODODECAN-3-OL

Dino Ferrante, Steven S. Tarquine, and William N. Setzer, Department of Chemistry, and P. Samuel Campbell, Department of Biological Sciences, The University of Alabama in Huntsville, Huntsville, Alabama 35899.

The medium-sized (mesocyclic) ring trithioethers, 1,4,7-trithiacyclodecan-9-ol (hydroxy-10S3), and 1,5,9-trithiacyclododecan-3-ol (hydroxy-12S3) have been synthesized and studied as potential ligands for the complexation of toxic trace metal ions ( $\text{Hg}^{2+}$ ,  $\text{Cd}^{2+}$ , and  $\text{Pb}^{2+}$ ). These mesocyclic trithioether ligands react with heavy metal ions to form stable, isolable complexes. Toxicity studies of the ligands themselves (mouse) show these materials to be well tolerated (no deaths within 30 days after administration and no noticeable difference in the animals' behavior) in doses as high as 3 g/kg.



THE DIFFERENTIATION OF 3,4-METHYLENEDIOXYMETHAMPHETAMINE (MDMA) FROM SOME REGIOISOMERS. J. DeRuiter, C. R. Clark and F. T. Noggle, Department of Pharmacal Sciences, School of Pharmacy and Department of Forensic Sciences, Auburn University, Auburn, AL 36849.

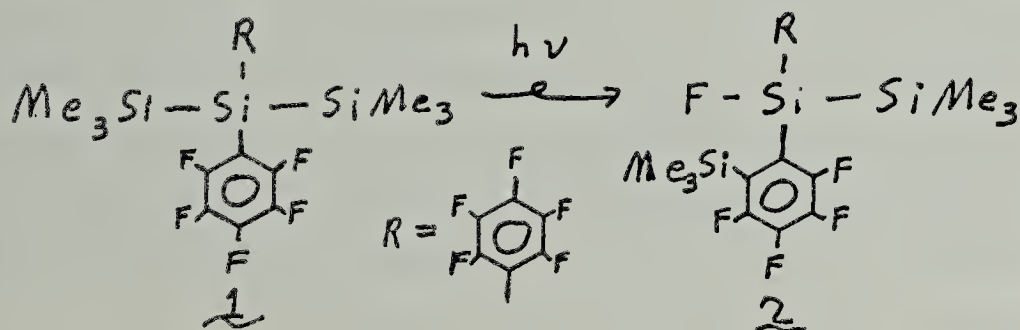
A number of N-substituted derivatives of 3,4-methylenedioxy-amphetamine (MDA), particularly the N-methyl analogue (MDMA), have been popular drugs of abuse in recent years. The continued interest in these compounds, as well as the appearance of new "designer drug" analogues in street samples has stimulated the development of efficient analytical methods to differentiate compounds of this structural class. In this study MDMA and three regioisomers were analyzed by infrared, ultraviolet, mass spectral and chromatographic methods. These compounds have very similar IR and UV properties, and all give rise to the same base peak ( $m/z = 58$ ) in the mass spectrum as a result of aminedominated fragmentation. MDMA and its regioisomers, however, can be readily differentiated by reversed phase liquid chromatographic techniques using an isocratic system consisting of a  $C_{18}$  stationary phase and an acidic mobile phase. The combination of chromatographic and spectroscopic methods allows for the rapid differentiation and specific identification of MDMA and closely related "designer drug" analogues.

SYNTHESIS AND EVALUATION OF AMIDE AND HETEROCYCLIC ANALOGUES OF THE PHENYLSULFONYLAMINO ACID ALDOSE REDUCTASE INHIBITORS. Kamal H. Bouhadir, J. DeRuiter and C. A. Mayfield, Department of Pharmacal Sciences, School of Pharmacy, Auburn University, Auburn, AL 36849.

The intracellular reduction of glucose to sorbitol by the enzyme aldose reductase (AR) has been implicated as an initiating factor in the etiology of chronic diabetic pathologies including neuropathy, nephropathy and retinopathy. Therefore there is considerable interest in the development of inhibitors of AR as potential therapeutic agents to prevent or delay the onset of these pathologies. In earlier studies we observed that a variety of N-phenylsulfonylamino acids (PSAAs) are effective inhibitors of AR in vitro. The goal of the present study was to assess the contribution of the acidic carboxyl moiety of the PSAAs toward inhibitory activity in compounds of this type. Titration revealed that the PSAA have  $pK_a$ s in the range of 3 - 4, and therefore are extensively ionized under in vitro assay conditions. Furthermore, the synthesis and evaluation of amide derivatives of the PSAAs demonstrated that replacing the carboxyl moiety with non- acidic or significantly less acidic moieties results in a substantial decrease in AR inhibitory activity. Based on these data, it appears that the carboxyl group of the PSAAs, or a moiety of comparable acidity is required for optimal interaction with the enzyme.

**PHOTOCHEMICAL REARRANGEMENT OF POLYSILANES DRIVEN BY THE FORMATION OF A SI-F BOND.** Lawrence F. Brough, Lamy Chopin, and James Flanagan, Spring Hill College, Mobile, AL 36608.

The silicon-fluorine bond is the strongest single bond known to chemistry. For this reason, its formation can be expected to provide a significant driving force for photochemically induced rearrangement reactions. As part of a program to investigate this approach we have chosen to prepare 2,2-bis(pentafluorophenyl)hexamethyltrisilane, 1, as a model compound. Photolysis at 254 nm in cyclohexane gives 1-fluoro-1-(2-trimethylsilyltetrafluorophenyl)tetramethyldisilane, 2, in 50% yield. Compound 2 has been characterized by X-ray crystal analysis and  $^1\text{H}$ ,  $^{13}\text{C}$ ,  $^{19}\text{F}$ , and  $^{29}\text{Si}$  NMR data has been obtained for both compounds. A mechanism for the rearrangement will be proposed. Unusual features of both the crystal structure and NMR spectra will also be discussed.



## TERPENOID CONSTITUENTS OF THE ESSENTIAL OIL OF RED CEDAR (*JUNIPERUS VIRGINIANA*)

Kylen W. Whitaker and William N. Setzer, Department of Chemistry, and Robert O. Lawton, Department of Biological Sciences, The University of Alabama in Huntsville, Huntsville, Alabama 35899.

The essential oil of red cedar (*Juniperus virginiana*) has been obtained from the needles of a number of individuals, both male and female, from different locations. These essential oils have been analyzed using gas chromatographic / mass spectral techniques. The terpenoid constituents and relative abundances have been determined in order to answer some intriguing chemical/ecological questions of importance to our locality: (1) Does terpene content differ between male and female *Juniperus virginiana* at a given site? (2) Does terpene content differ between "natural" cedar stands on southern exposures, rocky outcrops of Cumberland Plateau and successional cedar stands invading old fields? (3) Does the terpene content of bagworm-infested cedars differ from that of cedars without bagworms?

**BIRADICAL INTERACTIONS WITH FIRST AND SECOND ROW HYDRIDES.** P.V.Sudhakar and K. Lammertsma. Dep Of Chemistry, University Of Alabama in Birmingham, Al 35294.

Biradicals are reactive intermediates that may be obtained by the loss of a pair of bonding atoms from saturated species. They typically either add across a double bond or insert into a single bond. The insertion reaction of biradicals into main group hydride bonds will be discussed based on ab initio molecular orbital theoretical results. Electron density properties have been used to elucidate bonding in structures optimized using correlated levels of theory. The focus will be on the biradicals from group 15, viz., singlet NH and PH, which show interesting bonding phenomena. Comparison with biradicals of group 14, i.e., carbenes and silylenes will be made and particular emphasis will be given to effects electronegativity differences. The stabilities of the intermediate complexes involved in the insertion process and the barriers for subsequent hydrogen migrations will also be evaluated.

**MONTE CARLO INVESTIGATION OF EXPONENTIAL LEAST SQUARES.** Jason P. Weisenseel and Michael B. Moeller, Department of Chemistry, University of North Alabama, Florence AL 35632.

In analyzing data from a first order kinetics reaction, the data is commonly plotted in the semi-log mode. A weighted linear regression is then used to analyze the semi-log model. There is a bias introduced by the log transformation of the semi-log model. Even using the true weights for the weighted linear regression does not eliminate the bias in the slope calculation. Therefore the only way to eliminate the bias would be to analyze the data by the nonlinear least squares fit of the exponential model. This paper describes a Monte Carlo investigation of the accuracy the non-linear least squares fit to the exponential model. The results revealed that there was virtually no bias in the non-linear least squares fit to the exponential model. In addition, software was developed which would display the data in the semi-log mode for the human observer to examine, but do the parameter fitting to the exponential model.



**DETERMINATION OF TROPOSPHERIC CARBONYLS IN RURAL ALABAMA.** Valarie G. Henry, V. Kirk James, Allen Voss, III, Jane S. Harris and Thomas P. Murray. Department of Chemistry, University of North Alabama, Florence, AL 35630. Hal Westberg, Laboratory for Atmospheric Research, Washington State University, Pullman, WA 99164.

Project ROSE (Rural Oxidants in the Southern Environment), a comprehensive atmospheric study, was undertaken at a rural site in Sumter County between June 3 - July 21, 1990. One of the goals of the study was to examine the connection between biogenic hydrocarbons and ozone production in the rural south. Our contribution involved determination of airborne concentrations of formaldehyde, acetaldehyde, acetone and propionaldehyde at the site. These carbonyl compounds were determined using silica cartridges coated with 2,4-dinitrophenylhydrazine. The exposed cartridges were eluted, and the hydrazone derivatives analyzed by HPLC. The methodology will be discussed and QA\QC data will be presented. Using 2 hour integrated sampling periods between 6 A.M. and 11 P.M. over 200 samples were taken and subsequently analyzed during the course of the study.

**NEOTROPICAL NATURAL PRODUCTS: ANTIMICROBIAL ACTIVITY OF ESSENTIAL OILS OF FLORA FROM MONTEVERDE, COSTA RICA**

Kendall G. Byler, Amanda F. Setzer, and William N. Setzer, Department of Chemistry, Robert O. Lawton and Debbie B. Windham-Carswell, Department of Biological Sciences, The University of Alabama in Huntsville, Huntsville, Alabama 35899.

Tropical plant materials from the families *Rutaceae*, *Myrtaceae*, *Rubiaceae*, and *Proteaceae* have been collected from the Monteverde Cloud Forest Reserve, Costa Rica, as well as around the Monteverde community. Essential oils from these plants were obtained by steam distillation. The essential oils obtained from these tropical plants were analyzed by gas chromatographic / mass spectral techniques and were tested for fungicidal and bacteriocidal activity. Essential oils from flowers of *Guettarda poeana* and from leaves of *Zanthoxylum melanostichum* exhibited antifungal activity. The essential oil (0.1% solution) of *Z. melanostichum* was effective in inhibiting growth of all three of the fungi tested (*Saccharomyces cerevisiae*, *Candida albicans*, and *Aspergillus niger*) while that of *G. poeana*, interestingly, was effective against both *C. albicans* and *S. cerevisiae*.

## Abstracts

EXTENDED SURFACE MODIFICATION OF QUANTUM SEMICONDUCTOR PARTICLES. Catherine P. Childress, Marchelle Ledford, William N. Setzer, and Richard S. Lumpkin; Department of Chemistry; The University of Alabama in Huntsville; Huntsville, AL 35899

General interest in quantum semiconductor particles arises from their structural similarity to bulk semiconductors and their electronic similarity to molecular complexes.<sup>1</sup> Our principle interest is in development of new photoredox catalysts based the excited states of the quantum particles. Quantum particles of cadmium sulfide are synthesized by addition of an organic, "capping" ligand to a reaction mixture of  $\text{Cd}^{2+}$  and  $\text{S}^{2-}$ . Dependent upon its relative concentration, the ligand arrests particle growth at a specific size. Thiophenol is the most frequently used "capping" ligand<sup>1</sup> but it is limited in both scope and in the extent of its electronic interaction with the particle. To further control particle size, enhance the electronic properties of the particles, and provide accessible sites for chemical modification, we are investigating a series of phosphine and polypyridine ligands. Results of the synthesis and characterization of particles based on these new ligands will be presented.

1. Steigerwald, M. L.; Brus, L. E. *Acc. Chem. Res.* **1990**, *23*, 183-188 and references therein.

## SYNTHESIS AND COMPLEXATION STUDIES OF MESOCYCLIC TRITHIOETHERS

Norman L. Burns and William N. Setzer, Department of Chemistry, The University of Alabama in Huntsville, Huntsville, Alabama 35899.

The medium-sized (mesocyclic) ring trithioethers, 1,4,8-trithiacycloundecane (11S3), and 1,5,9-trithiacyclododecane (12S3) have been synthesized and studied as potential ligands for the complexation of transition metal and heavy metal ions. Ketone and alcohol analogs, keto-11S3, keto-12S3, hydroxy-11S3, and hydroxy-12S3, have also been synthesized and studied. Complexes of 11S3 or 12S3, or their ketone or alcohol analogs, with  $\text{Fe(II)}$ ,  $\text{Co(II)}$ , or  $\text{Ni(II)}$  apparently give *bis* octahedral complexes but these complexes are unstable with respect to hydrolysis. The mesocyclic trithioether ligands also react with heavy metal ions such as  $\text{Hg(II)}$  or  $\text{Pb(II)}$  to form stable, isolable complexes. Reaction of these ligands give various stoichiometric products (ligand/metal), often resulting in reduction, in the case of  $\text{Hg(II)}$ , of the metal center.



CONFORMATIONAL ANALYSIS OF MULTISITE-DIRECTED ALDOSE REDUCTASE INHIBITORS, R. Alan Davis, J. DeRuiter, C. A. Mayfield and T. Elder, Department of Pharmacal Sciences, School of Pharmacy and Department of Forestry, Auburn University, Auburn, AL 36849.

The three regioisomers 2-, 3- and 4-(benzoylamino)phenylsulfonylglycine (2-, 3- and 4-BAPSG) exhibit varying degrees of aldose reductase inhibitory activity, depending on the position of the benzoylamino substituent. The variability in affinity for this enzyme arises from differences in position and relative conformation of the benzoylamino (BA) or substrate-site moiety versus the conformation of the phenylsulfonylglycine (PSG) or inhibitor-site moiety. The conformations of the 2-, 3- and 4- BAPSG regioisomers was determined using molecular modeling with solution NMR data (2-D NMR or NOESY). Based on these studies, the BA moiety appears to be accessible to the substrate binding site of aldose reductase when it is extended from the from the PSG moiety and the aromatic rings of each of these groups are in a trans configuration about the amide bond. Also, binding of both moieties is optimized when the BA portion exists on the opposite side of the PSG plane. Based on these results, a model of the substrate and inhibitor binding sites of aldose reductase has been developed.

#### NEOTROPICAL NATURAL PRODUCTS: ANTIMICROBIAL AND CYTOTOXIC ACTIVITY OF CRUDE EXTRACTS OF *ARALIACEAE* FROM MONTEVERDE, COSTA RICA

Melody A. Thompson, Jin Huang, and William N. Setzer, Department of Chemistry, Robert O. Lawton and Debra M. Moriarity, Department of Biological Sciences, The University of Alabama in Huntsville, Huntsville, Alabama 35899.

Tropical plant materials from the ginseng family (*Araliaceae*) have been collected from the Monteverde Cloud Forest Reserve, Costa Rica, as well as around the Monteverde community. These plants were extracted (ethanol extraction, and chloroform extraction) and the crude extracts tested for fungicidal and bacteriocidal activity. None of the crude extracts showed antibacterial activity. Chloroform extracts from various *Oreopanax* spp. did show antifungal activity however. Ethanol extracts of various *Araliaceae* were examined for possible cytotoxic activity against HEP G2. Extracts from *Oreopanax sanderianus* and *Dendropanax quercetii* showed remarkable cytotoxic activity against this cell line.



POLY(ETHYLENE OXIDE-ALKENE) BLOCK COPOLYMERS: SYNTHESIS, CHARACTERIZATION AND POTENTIAL USES. Wendi S. Barner-Greene and Adriane G. Ludwick, Chemistry Department, Tuskegee University, Tuskegee, AL 36088.

An attempt is being made to synthesize a poly(ethylene oxide) (PEO) and acrylic acid (AA) block copolymer according to a literature preparation (Y. Minoura and A. Nakano, Macromolecular Syntheses, Collective Volume 1, John Wiley and Sons, 1977, pp. 409-411) of a PEO and methyl methacrylate (MMA) block copolymer. A similar synthesis is also being attempted using a water solution of PEO and acrylamide (AM). The potential block copolymers are being characterized by infrared and nuclear magnetic resonance spectroscopy. Viscosity, solubility, and melting point measurements are also being used. Initial data from these characterizations suggest that a small amount of the polymer from the AA, MMA or AM has been incorporated into the PEO. Appropriate controls have been run. Grafting of nucleic acid base pendants to the AA containing block copolymer will be attempted. Testing for antiviral activity at Southern Research Institute in Birmingham, AL, is planned. The support of the National Institutes of Health/Minority Biomedical Research Support program is gratefully acknowledged.

SYNTHESES AND SODIUM CHANNEL BINDING ACTIVITIES FOR DIPHENYL HYDANTOIN ANALOGS. Milton L. Brown and Wayne J. Brouillette, Department of Chemistry, University of Alabama at Birmingham, Birmingham, AL 35294.

The widely used anticonvulsant 5,5-diphenylhydantoin (phenytoin or DPH) binds to the neuronal voltage-sensitive sodium channel in a voltage- and frequency-dependent manner. Significant binding occurs at physiologically relevant concentrations, suggesting that the sodium channel may be an anticonvulsant "receptor site" for DPH. We have been interested in determining requirements for optimum binding to this site. Previous studies suggested that the binding site for DPH may require a specific aromatic ring orientation. In order to further investigate this possibility, we recently investigated several simple 5-alkyl-5-phenylhydantoins which contained varying constraints for the orientation of the 5-phenyl ring. Their syntheses and sodium channel binding activities will be presented. (Supported in part by NIH NS23866).

## Restricted Rotation in Arenetricarbonylchromium Complexes.

R. Brown, J. Hamilton, C.A.L. Mahaffy, J. Rawlings and R. Wheat,  
Department of Chemistry, Auburn University at Montgomery,  
Montgomery, AL 36117-3596.

The use of tricarbonylchromium group as a stereochemical probe in the investigation of restricted rotation of polyalkylated anilines will be described. Two different signals for the  $\text{NMe}_2$  groups in the N,N,2,4,6-pentamethylanilinetricarbonylchromium are seen in both  $^1\text{H}$ - and  $^{13}\text{C}$ -Nmr indicating restricted rotation of this group in these systems.

Analysis of the temperature dependence of the  $^1\text{H}$ -Nmr spectrum of N,N,2,4,6-pentamethylanilinetricarbonylchromium showed coalescence of the two methyl group signals at 282K, which yields the thermodynamic data given below. The values determined from the experiments reported here are in line with those reported for restricted rotation in other  $\text{NMe}_2$  systems where the activation energies show variations from 6 to 15 kcal per mole.

TABLE 1 Kinetic and Thermodynamic Data for Restricted Rotation  
in N,N,2,4,6-Pentamethylanilinetricarbonylchromium

$T^a$	$K^b$	$E_a^c$	$\Delta G^{*c}$	$\Delta H^{*c}$	$\Delta S^{*d}$
282	14.37	12.15	13.69	11.59	-7.45
a) degrees K	b) $\text{sec}^{-1}$	c) kcal/mole	d) eu		

Further studies concerning other sterically hindered arenetricarbonylchromium systems are currently being performed in these laboratories.

## APPLICATIONS OF ELECTRON DENSITY ANALYSES.

Koop Lammertsma and Pamidighantam V. Sudhakar. Department of Chemistry, University of Alabama at Birmingham, Birmingham, AL 35294.

C-C bonds form the frame of organic molecules. To what extent can such bonds be compressed or elongated and how much energy can be stored in them are questions of great importance. In this *ab initio* theoretical study we explore the properties of bonding in two systems. In the first, we evaluate the bonding in various homoaromatic cations on which there is a great amount of experimental information. In the second group, we compare the bonding between the inverted carbons in both rhombic  $\text{C}_4$  and [1.1.1]propellane. The nature of C-C bonding in these systems is discussed by means of Bader's topological electron density analysis, which is based on the theory of atoms in molecules.

**REACTIVITY OF  $\text{Me}_2\text{AsNMe}_2$  TOWARDS ORGANO-ALUMINUM/MAGNESIUM REAGENTS.** C. J. Thomas, L. K. Krannich, and C. L. Watkins. Department of Chemistry, University of Alabama at Birmingham, Birmingham, AL 35294.

As part of our investigations on the reactivity of aminophosphines and aminoarsines with Group 13 Lewis acids, we have been successful in showing that aluminum alkyls readily cleave the As-N bond to provide a new synthetic route to homoleptic tertiary arsines. We have also established that aminoarsines also react with Grignard reagents to give tertiary organoarsines. In this paper, we describe a new high yield synthesis of several heteroleptic tertiary organoarsines of the type  $\text{Me}_2\text{AsR}$  [ $\text{R} = \text{Et}, \text{Pr}^n, \text{Pr}^i, \text{Bu}^n, \text{Bu}^i, \text{Bu}^t, \text{allyl}, \text{Me}_3\text{SiCH}_2, \text{Ph}, \text{p-tolyl}, \text{Bzl}, \text{and mesityl}$ ] by using  $\text{Me}_2\text{AsNMe}_2$  as the parent arsine. The utility and limitations of the Grignard reagents and aluminum alkyls as alkylating agents in these syntheses will be discussed. The  $^{13}\text{C}$  and  $^1\text{H}$  NMR and mass spectral data for the synthesized arsines will be presented.

**MECHANISTIC STUDIES OF ANHYDRIDE-IMINE CONDENSATIONS** Venkatram reddy Atigadda and Forrest T. Smith, School of Pharmacy, Auburn University, Auburn, Alabama 36849.

The reaction of 7-methoxyisobenzopyran-1,3-(4H)-dione with various heterocyclic imines has been shown to be a useful method of preparing a number of tricyclic heterocycles. While oxazole and thiazole fail to react, the more basic 2-oxazoline, 2-thiazoline and 2-imidazoline all react readily at room temperature. The initial step appears to be an enolization of the anhydride which is a function of the basicity of imine. The enol may exist in a number of possible isomeric forms. Molecular modeling of the isomeric forms and possible transition states has allowed predictions to be made regarding the reactivity of additional heterocycles. The reaction of the anhydride with acrolein in the presence of a catalytic amount of triethylamine (TEA) proceeded to give the 1,2 addition product. The reaction of the anhydride with dimethylacetylene dicarboxylate also proceeded quickly at room temperature when a catalytic amount of TEA is added. Previously it was believed that harsher conditions were necessary to accomplish this transformation.



## Abstracts

SYNTHESIS OF NOVEL SUGAR-BASED POLYAMIDES. Liang Chen and Donald E. Kiely, Department of Chemistry, University of Alabama at Birmingham. UAB Station, AL 35294.

During the investigation of polyamides based on sugar and diamine monomers, a variety of novel polyamides have been synthesized : 1) Nylon analogue polyamides including poly-(hexylmethyleneglucaramide), poly(decylmethyleneglucaramide) and poly(hexylmethylenexylaramide) ; 2) Potential photo-degradable and biodegradable polyamides, e.g. poly(m or p-xylyleneglucaramide) ; 3) Dendrimers, a new category of polymers which utilize trifunctional monomer based on tris(2-aminoethyl)amine and glucaric acid. By differentiating the reactivity of glucarolactone and diamine, stereoregular polyamides may be synthesized.

HINDERED ROTATION IN THE STRYENETRICARBONYLCHOMRIUM COMPLEXES. J. Rawlings, C.A.L. Mahaffy, A. Grler, and H. Khuu, Dept. of Chemistry, Auburn University at Montgomery, Montgomery, AL 36117.

Substituted acetophenonetricarbonylchromium complexes have been found to have unexpected spectral properties when the substitution pattern involved 2,6-groups. This has been interpreted as an unusual geometry of the arene ring caused by the steric crowding from the substituents in the 2,6 position. This same phenomenon has been investigated with 2,6-disubstituted styrene and ester complexes.

PREPARATION AND PROPERTIES OF UREA FLUOROSILICATE. Richard C. Sheridan, TVA (retired), 105 Terrace Street, Sheffield, AL 35660.

Urea fluorosilicate,  $(\text{NH}_2\text{CONH}_2)_4 \cdot \text{H}_2\text{SiF}_6$ , was prepared by mixing urea and 30% fluorosilicic acid in a mole ratio of 4.0 and dewatering the resulting solution to produce crystalline product. The yield was virtually 100%. The compound has an X-ray diffraction pattern different from that of urea fluorosilicate having the same chemical composition but made from urea, methanol, and silicon tetrafluoride. Several potential applications have been reported for urea fluorosilicate and it could be made using by-product fluorine from the phosphoric acid industry.

## Abstracts

CHIRAL SYNTHESIS OF CYCLITOLS DERIVED FROM D-GLUCOSE.  
Donald E. Kiely and David W. Morton, Dept. of Chemistry,  
Univ. of Ala. at Bham., Birmingham, AL 35294.

A general synthetic scheme for the preparation of  
cylitols derived from D-glucose via 6-deoxy-6-substitut-  
ed-5-keto-glucofuranose derivatives will be presented.

## GEOLOGY

PROGRESS TOWARD UNDERSTANDING THE PETROGENESIS OF ANORTHOSITE IN  
THE STILLWATER COMPLEX, MONTANA: THE BULK COMPOSITION OF AN-II. Keith  
D. Pass and Peter A. Salpas, Dept. of Geology, 210 Petrie Hall, Auburn University, AL 36849-5305.

Outcrop-scale chemical and mineralogical heterogeneities of anorthosite layers in the Middle Banded series of the Stillwater Complex, Montana argue for solidification from a crystal/liquid suspension. Knowledge of the bulk compositions of these layers is important to understanding the manner in which the suspension solidified by providing parameters which allow us to evaluate petrogenetic processes such as fractional crystallization and compositional convection of the interstitial liquid. We are attempting to estimate the composition of one of these layers (AN-II, 570 meters thick) by determining average compositions of two outcrops - one from the bottom of the layer and one from its top - and combining these data with the average composition of an outcrop from the middle of the layer which has been reported previously. Our work in progress shows that the average composition of AN-II, as determined from the three outcrops, is consistent with the plagioclase-rich nature of the layer. It is enriched in  $\text{Al}_2\text{O}_3$  (28.05 wt.%), and CaO (14.48 wt.%) and depleted in the ferromagnesian elements (FeO: 2.88 wt.%; MgO: 1.83 wt.%) and incompatible trace elements (e.g., La: 2.1 ppm; Hf: 0.35 ppm; Th: 0.26 ppm) relative to common basaltic magmas. The average compositions of the three outcrops show some distinct differences in composition that exceed analytical uncertainties. For instance, the outcrop at the bottom of AN-II is enriched in the following elements relative to the outcrops from the middle and top: FeO (3.14 wt.% vs. 2.77 and 2.74 wt.%, resp.), Cr (36.3 ppm vs. 10.1 and 12.4 ppm, resp.), Ni (51 ppm vs. 24 and 36 ppm, resp.), and the outcrop at the top of AN-II is enriched in the following elements relative to the outcrops from the middle and bottom of the layer: Br (1.16 ppm vs. 0.64 and 0.63 ppm, resp.); La (3.23 ppm vs. 1.62 and 1.45 ppm, resp.); Yb (0.52 ppm vs. 0.41 and 0.38 ppm, resp.). It appears that, in general, AN-II is enriched in the ferromagnesian elements near its base and enriched in the REE and certain other incompatible trace elements near its top. These compositional differences are consistent with fractional crystallization, in which the more mafic, incompatible-element-poor minerals crystallized first at the bottom of the suspension. However, the data do not rule out compositional convection during which a dense reject solute sank through the suspension and incompatible elements rose to the top.



## Abstracts

CYCLICITY IN THE DEMOPOLIS CHALK (UPPER CRETACEOUS), WESTERN ALABAMA.  
Charles E. Savrda, Timothy M. Demko, and Michael W. Smith, Department  
of Geology, Auburn University, AL 36849-5305.

The lower unnamed member of the Upper Cretaceous (Campanian) Demopolis Chalk of western Alabama is characterized by a pronounced decimeter-scale carbonate cyclicity. A 20-meter-thick section of the Demopolis exposed at Port of Epes, Sumter County, is currently the subject of a pilot study designed to assess the character and causes of this rhythmic bedding. Carbonate and organic-carbon curves generated from analyses of closely-spaced samples reveal two orders of cyclicity. Shorter-term cycles, defined by light-and-dark bedding couplets with an average thickness of ~61 cm, are superimposed upon low-amplitude, low-frequency cycles. The latter cycles are defined by bundles of four to five bedding couplets (average bundle thickness = ~2.9 m). In the absence of detailed biostratigraphic control and adequate data on short-term sedimentation rates, the periodicities of the two cycles are difficult to assess. Assuming that the entire lower member of the Demopolis is 130 m thick and was deposited at a roughly uniform rate during a period of 4.5 my, periodicities of the short- and long-term cycles are approximately 21 and 105 ky, respectively. These periodicities are close to that of the Milankovitch cycles of axial precession and orbital eccentricity and, therefore, suggest that Demopolis cyclic sedimentation may have been modulated by climate perturbations. The specific paleoceanographic mechanism(s) responsible for this cyclicity (e.g., variations in redox conditions, bottom-current energy, productivity, dissolution, and/or dilution by clastic sediments) are currently being assessed through detailed ichnological, paleontological, petrographic, and stable isotopic studies.

## BASEMENT-COVER RELATIONS AND TECTONOSTRATIGRAPHY ALONG THE WESTERN GNEISS REGION OF OFOTEN, NORTH NORWAY

VAN WINKLE, S.W., and STELTENPOHL, M.G., Dept.  
of Geology, Auburn University, Auburn, AL 36849-5305,  
U.S.A., A. ANDRESEN, University of Oslo, P.O. Box 1047,  
Blindern, 0316 Oslo 3, Norway

Rocks of East Grytoya, Sandsoya, Akeroya, Kjotta, and several adjacent islands represent four Caledonian tectonic settings: (1) pre-Caledonian crystalline basement (Western Gneiss region, WGR), including intrusively enclosed supracrustals, (2) its autochthonous/paraautochthonous Eocambrian/Cambrian (?) metasedimentary cover, (3) allochthonous metasedimentary units and granitoid slivers possibly corresponding to the Lower and Middle Allochthons, and (4) the Upper Allochthon Salangen Group. Mapping in this area indicates that Salangen Group lithologies incorrectly have been included within the Lower Allochthon on earlier maps. Differentiating these units help to define the structural configuration of lithotectonic units along the western limb of the Ofoten synform. Several slivers of red potassium feldspar granitic rock bounded by orthoquartzite, graphitic schist, mica schist, and dolomitic marble are interpreted as imbricated slices of Precambrian basement and its attached cover. These units contain amphibolite-facies metamorphic mineral assemblages. Plastic shear zones in the basement complex are commonly associated with supracrustal enclaves and appear to parallel the basement-cover contact. Sense-of-shear studies on these shear zones, based on extensional shear bands, porphyroclast systems, and S-C composite planar fabrics, indicate top-to-the-NE transport along the shallow SE-dipping shear surfaces. The basement-cover contact and these plastic shear zones are modified by: (1) tight, shallow NE-plunging F2 folds; (2) broad, shallow SE-plunging F3 crossfolds; and (3) vertical, N70E trending late-stage microbreccia zones that reach thicknesses of over 100m. Correlations with adjacent areas have implications for the tectonic style of this controversial basement-cover contact and late-stage faults that complicate the geometry of the western limb of the Ofoten synform.



## Abstracts

RELATIONSHIPS BETWEEN TEREDOLITES, XYLIC SUBSTRATES, AND SEA-LEVEL DYNAMICS: EVIDENCE FROM THE ALABAMA COASTAL PLAIN. Charles E. Savrda, Department of Geology, Auburn University, AL 36849-5305.

Allochthonous logs and/or Teredolites (clavate borings produced in xylic substrates, primarily by bivalves) occur in extraordinary abundance in some Cretaceous and Tertiary marine depositional sequences exposed in the Alabama coastal plain. All occurrences recognized thus far are restricted to transgressive systems tracts (particularly transgressive lag deposits and condensed sections) and, therefore, appear to be related to sea-level rise. Three mechanisms are proposed to explain this relationship: 1) the inundation of forested coastal plain settings during transgression results in an influx pulse of xylic substrates into marine and marginal marine environments; 2) erosion associated with continued landward migration of the shoreface results in the exhumation and hydraulic concentration of logs after their initial deposition in marginal marine settings; and 3) owing to the landward trapping of terrigenous sediments during transgression, xylic substrates that are transported offshore as driftwood and eventually sink in deeper quiet marine settings are concentrated via sediment starvation. The proposed relationships between fossil wood, ichnofossils produced therein, and sea-level dynamics have implications regarding 1) the recognition of sequence stratigraphic packages and their bounding surfaces, 2) the exploration for woody components of terrestrial fossil floras in marine rocks, and 3) the stratigraphic distribution and biological evolution of wood-boring bivalves and other faunal occupants of xylic substrates (e.g., pseudoplankton).

ANALYSIS OF GEOLOGIC MATERIALS BY NEUTRON ACTIVATION AT AUBURN UNIVERSITY. Peter A. Salpas, Department of Geology, 210 Petrie Hall, Auburn University, AL 36849-5305.

Neutron activation is recognized as the most precise technique for analysis of many elements that occur in trace quantities ( $<0.01$  wt.%) within geologic materials. Recently, high precision analyses of trace elements have been conducted by neutron activation in the Leach Nuclear Science Center at Auburn University. Rock samples are first powdered to a maximum grain size of 75 micrometers then 200 mg aliquots are sealed in ultrapure silica tubes. The samples, along with standard powders of known elemental concentrations, are then irradiated in a neutron flux of about  $5 \times 10^{13}$  neutrons/cm<sup>2</sup>/sec for between 10 and 20 hours at the University of Missouri's Research Reactor. The neutron irradiation produces radioactive isotopes of many elements in the samples and standards. After about a week, the irradiated samples are returned by courier to Auburn University for counting of gamma rays that are given off during decay of the radioactive isotopes. Counting is conducted using two detectors (one GeLi and one high purity Ge) and appropriate electronics for signal processing. Raw data are accumulated with the aid of a 286 microcomputer equipped with two Nuclear Data multi-channel analyzer boards. Gamma ray peak areas are calculated with the Nuclear Data ASAP program and elemental abundances are calculated in a Lotus 1-2-3 spreadsheet. The abundance calculations rely on the fact that the isotopes of interest emit gamma rays with characteristic energies and the intensities of the gamma rays (i.e., the count rate) are proportional to the abundances of the isotopes. The calculations involve ratioing the peak areas of the samples to those of the standards with corrections for different masses, decay times, and count times. Other corrections are also built into the abundance calculations, for example, photopeak interferences, such as the 300.1 keV peak of <sup>233</sup>Pa interference with the 298.6 keV peak of <sup>160</sup>Tb, and induced fission products of U isotopes that occur in the samples.

## Abstracts

INTRODUCTORY GEOLOGY STUDENTS-- WHAT DO THEY NEED TO KNOW? Thomas J. Carrington, Dept. of Geology, Auburn Univ., AL 36849-5305.

Suggested remedies for the depression in the job market and the reduced numbers of majors in the geological sciences have included training and re-training of public school teachers, funding for public school curriculum development, providing up-to-date information on the job market to high-school counselors, and awards programs for outstanding teachers. Suggested remedies for the more recently recognized failure of college- and university- level introductory courses in sciences, mathematics, and engineering to retain students planning to major in those fields include revising curricula; development of interdisciplinary courses and/or curricula; revision of funding agencies' emphasis on teaching/research priorities; and revision of criteria for tenure, promotion, and salary improvement. However, to paraphrase Pogo, "We is meeting the enemy, and they is us." Teachers of introductory geology courses and authors of geology textbooks should realize that students in these courses do not need to know everything the teacher/author knows, no matter how interesting to professional geologists, editors, or reviewers. Why include so many (up to 1000) special terms to be memorized by the vast majority of students who will never use them again? Why include expensive, multi-color drawings so many times (variations of subduction zones are repeated as many as ten times in some texts)? Why include detailed diagrams that are easier to ignore than understand? Why include rambling, often obscure, discussions on details that are unimportant to the story being developed? More care should be taken to address the proper audience and tell the elegant story of science and its applications to planet Earth and its history-- without the agonizing and superfluous details.

GEOLOGY OF BENTONITE DEPOSITS IN LOWNDES COUNTY, ALABAMA. Lewis S. Dean, Geological Survey of Alabama

Economic-grade bentonite deposits in Upper Cretaceous formations of Alabama were first reported in 1940 approximately 2 miles north of Sandy Ridge, southeastern Lowndes County. Mining operations were initiated in 1964 and since 1971 there has been an average annual production of approximately 174,000 short tons of bentonite for use in foundry and agricultural industries. Nonswelling calcium bentonite deposits occur near the base of the Ripley Formation and are the only commercial-grade bentonite deposits mined from the Selma Group in the southeastern Gulf Coastal Plain. Very light- to medium light-gray bentonite occurs as lense-shaped bedded deposits (with localized low-angle crossbedded sections) from less than 5 feet and up to 20 feet thick. X-ray diffractograms of quarried bentonite identify the clay size mineralogy to be smectite with trace amounts of illite, quartz, and cristobalite. Biotite and sericite are common nonclay impurities (phenocrysts?) occurring as megascopic plates up to 1 mm wide. Scanning electron microscope photomicrographs of bentonite illustrate authigenic angular and platy smectite clay morphology. Chemical composition of Lowndes County bentonites show diagenetic exchangeable cations in smectite of Ca (1.9 to 2.7% CaO) over Na (<0.01% Na<sub>2</sub>O) with variable MgO (3.7 to 5.5%) and Fe<sub>2</sub>O<sub>3</sub> (1.4 to 4.9%). The geology of bentonite deposits in Lowndes County indicate these clay horizons were produced by devitrification and chemical alteration of a volcanic ash source material--an origin similar to that of other bentonite deposits in the Gulf Coastal Plain.



## Abstracts

### FORESTRY, GEOGRAPHY, CONSERVATION, AND PLANNING

CHANGES IN THE INTERNATIONAL FLOW OF U.S. INWARD FOREIGN DIRECT INVESTMENT. Jeffrey P. Richetto, Department of Geography, The University of Alabama, Tuscaloosa, AL 35487.

Since World War II the emergence of a new integrated global system of manufacturing production, trade, and direct investment has occurred primarily through techno-economic restructuring, liberal/protectorate trade and capital investments, and the transnational corporate environment. The development of technology in the form of production, transportation and communication along with system mechanisms permit corporations to engage in the exchange of materials and information with greater speed, efficiency, diversity and geographic extensiveness. In effect, the availability of these technical innovations have created an increasingly more mobile, location-production environment and has allowed the firm to avail itself to a global network of information on options and opportunities. Resultantly, corporations worldwide have increasingly organized their planning strategies at the national and especially international levels. As this new international corporate environment continues to unfold the earlier advantages of centralized production have been virtually eliminated; therefore, requiring a firm's presence in major world markets. In response there has been a deluge of foreign investments transacted throughout the world economy characterized by an ever growing number and capital value of investments, an ever larger list of investor countries, and of critical importance to the United States a reversal in the flow of foreign direct investments, FDI. Within this context this paper examines changes in the international flow of U.S. inward FDI between 1974-1988. Specifically, changes in the number, type, proportional share and locational preferences of investor countries are examined.

GIS DEVELOPMENT FOR A COUNTY WATER SYSTEM: PILOT PROJECT. Priscilla Holland, Geographic Research Center, Univ. of North Ala., Florence, AL 35632-0001.

The goal of this pilot study, funded by the Alabama Department of Economic and Community Affairs (ADECA), was to establish the feasibility of developing and maintaining a county water line database. The project required the compilation of available information on water lines in Lauderdale, Colbert, Franklin, Marion, and Winston Counties. This information was then digitized into a Geographic Information System (GIS) database that could be expanded and updated. A data design was developed for displaying water lines as map products to be used by the Northwest Alabama Council of Local Governments (NACOLG) in their grant writing process.



## Abstracts

SPATIAL PATTERNS OF DROUGHT FREQUENCY AND DURATION IN THE CONTIGUOUS UNITED STATES. Peter T. Soulé, Dept. of Geography, Univ. of Ala., Tuscaloosa, AL 35487-0322.

This study examines patterns of drought frequency and duration in the contiguous United States based on multiple definitions of drought events. Patterns are examined using data from the three Palmer indices: monthly moisture anomaly index, drought severity index, and hydrologic drought index. The data span a 94-year period and are spatially aggregated to the climatic division level. The stimulus for this study is the lack of systematic examinations of the possibility of varying patterns of drought frequency and duration among the drought types represented by these indices. Isoline maps of mean drought frequency indicate that the index used to define a drought has a major impact on the spatial patterns. Patterns identified using the monthly moisture anomaly index are nearly inverse of those for the drought severity and hydrologic drought indices. Patterns of drought duration also vary among the indices, although previous findings of greater drought persistence in the interior regions of the United States were upheld by all three indices. Results also indicate that varying the parameters (intensity, minimum duration) of an index-specific drought event definition has only a minor impact on the spatial patterns.

SOCIOECONOMIC IMPACT IMPLICATIONS OF NEPA. William K. McAllister, Department of Community Planning, Alabama A&M University, Huntsville, Alabama 35762.

While the National Environmental Policy Act (NEPA) was not originally designed to give primary consideration to social and economic impacts of federal actions, it is clear that if biophysical impacts have been determined to exist, NEPA should also analyze related socioeconomic impacts. This is accomplished by the Environmental Impact Statement (EIS). Socioeconomic analyses should consider both direct and indirect effects (impacts). Indirect effects "may include growth inducing effects and other effects relating to induced changes in the pattern of land use, population density or growth rate..." (40 CFR 1508.8). The cumulative effects of change must also be considered. Socioeconomic significance is typically triggered by the number of new jobs created by the proposed federal project. These new jobs generate new monies and more spin-off jobs, but the resulting growth demands more sophisticated and extensive urban services. No single threshold will work for analyzing all situations. However, once significance is determined to be likely, the EIS can become a device for presenting strategies for mitigation of possible adverse effects, such as traffic congestion, and for allaying public fears among proposed project neighbors, be they growth control or economic development advocates. The EIS can also be turned around by local communities and used like a strategic planning element within its own arsenal of economic development and fiscal management strategies. Better local/federal relations should result.

## Abstracts

EXAMINING GEOGRAPHY EDUCATION USING NGS'S WEATHER MACHINE AND GTV.  
Shan Burkhalter, Dept. of Geography, Univ. of North Ala., Florence,  
AL, 35632-0001.

In recent years an alarming deficiency in geographic knowledge has been realized. A 1988 Gallup organization release ranked Americans among the bottom third in an international test of geographic knowledge. This is an indication that something drastic must be done to revitalize America's teaching of geography. The National Geographic Society has long been a proponent of geography education. In light of numerous reports on America's ignorance of geography, Gilbert M. Grosvenor, the Society's president and chairman, stated in 1986 that "Education is my one priority--geographic education my major concern." This represents a fundamental shift within the Society toward filling this void in America's education. In its effort to revitalize geography education NGS has implemented programs aimed at teachers and students to enhance the understanding and teaching of geography. Among these, The Weather Machine and GTV are two exciting new programs recently created. These Educational Media releases represent a portion of the National Geographic Society's recommitment to geographic education.

A METHOD FOR SOLID WASTE MANAGEMENT USING THE NORTH ALABAMA  
GEOGRAPHIC INFORMATION SYSTEM. William R. Strong, Dept. of Geography,  
University of North Alabama, Florence, AL 35632.

The disposal of solid waste is a problem of immense local and national proportions. Gone are the days when dumping the "trash" of an affluent society could be accomplished with little fanfare by digging a large hole in the ground and then covering it up. Documentation of environmental hazards posed by uncontrolled and unmonitored "dump" sites and a "not-in-my-backyard" attitude have created serious problems in developing new sites for solid waste management. Using the North Alabama Geographic Information System (NAGIS) database, a methodology was developed in order to determine potential solid waste management sites in two counties of northwest Alabama. Information on political boundaries, urban areas, streams and other waterbodies, wetlands, 100 year flood plains, and transportation networks were extracted from NAGIS. Through a search and overlay procedure, a final composite map showing the location of potential site areas was derived.

## Abstracts

A GEOGRAPHICAL ANALYSIS OF EMERGENCY MEDICAL SERVICE IN CALHOUN COUNTY, ALABAMA. Thomas F. Baucom, Department of Geography and Anthropology, Jacksonville State University, Jacksonville, AL 36265.

The emergency medical service of Calhoun County was studied to determine the effective range of Advanced Life Support care provided to county residents by ambulance/rescue squads based in the county. A sample of response travel time and distances was obtained from each of the squads and used to derive an average ambulance speed in responding to emergencies. The average ambulance speed was employed with a critical response time for a cardiac arrest patient established by the American Heart Association to map the effective response range for ALS squads. This response range covered about 1/3 of Calhoun County leaving some 30,000 people at potential risk. ALS and first response squad locational factors were examined to determine feasible ways of maximizing the county area inside the ALS response range.

ASSESSING TRANSPORTATION NEEDS USING U.S. CENSUS DATA. Gail Clemons, University of North Alabama, Florence, AL 35632-0001.

This project, funded by the Urban Mass Transportation Administration, U.S. Department of Transportation, and administered by the Alabama Highway Department and the Northwest Alabama Council of Council of Local Government is to assess the current transportation system and provide information for future planning for the Northwest Alabama Transit Association (NATA) system in Lauderdale, Colbert, Franklin and Marion Counties.

This segment of the study assesses the unmet needs of the transportation disadvantaged. This is accomplished by using the 1980 U.S. Bureau of Census data. After collecting the necessary data into categories pertinent to this study, the planner will be able to impute an estimate of the handicapped dependent groups, using a prevalence factor applied to each age group. Upon completion of the calculations, the spatial concentrations will be displayed on maps.

LANDSCAPE SCENERY IN MAGAZINE ADVERTISEMENT. Ted Klimasewski, Dept. of Geography, Jacksonville State Univ., Jacksonville, AL 36265

Advertising through newspapers, magazines, radio and television is the engine which drives the capitalistic system and moves consumers in the complex American economy to buy, buy, buy. In printed and television advertisements, considerable emphasis is given to non-verbal cues appealing to sight. Some non-verbal advertisements are blatant, especially in the portrayal of sensual body language exhibited in blue jeans and cologne commercials, whereas others are subtle uses of facial expressions and subliminal stimuli. In addition to bodily expressions, another approach in non-verbal advertising is landscape. Supposedly, natural and human-made scenes set a non-verbal tone that stimulates an emotion, a correct attitude and appropriate behavior. And that is the focus of this study: The impact of landscapes in magazine advertising as they influence the emotion, attitude and behavior of consumers.



## Abstracts

FLORA OF NORTH AMERICA PROJECT. R. David Whetstone, JSU Herbarium, Jacksonville St. Univ., Jacksonville, AL 36265, and Nancy R. Morin, Department of Botany, Missouri Botanical Garden, St. Louis, MO 63166-0299.

The Flora of North America Project is designed to produce an encyclopedic account of ca. 17000 species of vascular plants or about 7% of the world's total that occur in North America, north of Mexico. Descriptions will be written and reviewed by experts from around the world and will be based minimally on observations of specimens (living and preserved) and a review of literature. The printed products will be a series of 12 volumes to be published by Oxford University Press, NY. Treatments will include scientific and vernacular names, descriptions, keys, maps, illustrations, summaries of habitat/distribution, relevant synonymies, and other observations. In addition, an electronic database contains data and other observations contained within the printed volumes with other information not conducive to inclusion with the printed volumes.

## PHYSICS AND MATHEMATICS

POSSIBLE WHITTAKER UNIFICATION OF ELECTROMAGNETICS, GENERAL RELATIVITY, AND QUANTUM MECHANICS. T. E. Bearden, Association of Distinguished American Scientists, 2311 Big Cove Rd., Huntsville, AL 35801.

Unrecognized for what it was, in 1903-1904 E.T. Whittaker (W) published a fundamental, engineerable theory of electrogravitation (EG) in two profound papers. The first (W-1903) demonstrated a hidden bidirectional EM wave structure in the scalar potential of vacuum, and showed how to produce a standing scalar EM potential wave -- the same wave discovered experimentally four years earlier by Nikola Tesla. W-1903 is a hidden variable theory that shows how to deterministically curve the local and/or distant spacetime using EM. W-1904 shows that all force field EM can be replaced by interferometry of two scalar potentials, anticipating the Aharonov-Bohm effect by 55 years and extending it to the engineerable macroscopic world. W-1903 shows how to turn EM into G-potential, curve local and/or distant spacetime, and directly engineer the virtual particle flux of vacuum. W-1904 shows how to turn G-potential and curvature of spacetime back into force-field EM, even at a distance. The papers implement Sahkarov's 1968 statement that gravitation is not a fundamental field of nature, but a conglomerate of other fields. Separately applied to electromagnetics (EM), quantum mechanics (QM), and general relativity (GR), an extended superset of each results. The three supersets are Whittaker-unified, so that a testable, engineerable, unified field theory is generated. EM, QM, and GR each contained a fundamental error that blocked unification, and these three errors are explained. The Schroedinger potential can also be structured and altered, indicating the direct engineering of physical quantum change. Recently Ignatovich has pointed out this hidden bi-directional EM wave structure in the Schroedinger potential, without referencing Whittaker's 1903 discovery of the basic effect. Coupling of photon/antiphoton pairs into spin-2 gravitons, and decoupling of gravitons to yield paired photons, follows and extends photobiology. An engineerable, hidden-variable theory of the operation of mind, personality, and memory can be constructed and tested. Some of the profound implications for all of physics and biology are pointed out.

COVALENT BONDING IN THE OCTAHEDRAL, HYDRATED COMPLEXES OF THE LANTHANUM ZINC DOUBLE NITRATE CRYSTAL FROM A MAGNETIC RESONANCE INVESTIGATION, Henry W. Glotfelty, Department of Physics, Samford University, Birmingham, AL 35229.

ENDOR (Electron Nuclear Double Resonance) spectra of  $^{17}\text{O}$  in water molecules of the complexes  $(\text{Mn} \cdot 6\text{H}_2\text{O})^{2+}$  in the two non-equivalent sites (the X and Y sites) of double nitrate crystals  $[\text{La}_2\text{Zn}_3(\text{NO}_3)_{12} \cdot 24\text{H}_2\text{O}]$  have been employed to obtain Fermi contact interactions  $A_s$  and transferred spin fractions  $f_s$ . The contact interactions arises from the transferred spin density in those molecular orbitals of the water molecules that have a finite amplitude at the  $^{17}\text{O}$  nucleus. The contact interactions found for the two non-equivalent  $^{17}\text{O}$ 's of the X site (OW2 and OW3) were  $-7.39(2)$  MHz and  $-7.27(2)$  MHz, respectively. For the Y site the contact interaction found for OW1 was  $-7.63(2)$  MHz. The transferred spin fractions were determined to be .063, .061, and .060 for OW1, OW2, and OW3, respectively. The above values are in reasonable agreement with the theoretical values using the wavefunctions of Andriessen.<sup>1</sup>

Research supported in part by a National Science Foundation Grant GH-34582. Helium gas supplied by Office of Naval Research Contract No. Nonr-2775(00).

<sup>1</sup>Andriessen, J. Mol. Phys., 23, 1103 (1972)

TIDAL PERTURBATIONS ON THE HYDROGEN ATOM NEAR A BLACK MINI-HOLE. John H. Young, Joseph G. Harrison, and J. Brad Bishop, Univ. Ala. at Birmingham.

Tidal effects resulting from differential gravitational forces over finite-sized bodies are well understood and demonstrated by the earth-moon system. We consider here the possible existence of tidal effects on the microscopical scale by examining the differential gravitational effects on a 1s hydrogen atom in the vicinity of a black mini-hole. The typical  $10^{16}$  g mass compacted to within a  $10^{-12}$  cm radius would be expected to produce significant differential gravity over small spatial regions several Bohr radii away. A hydrogen atom at such a location would thus be subjected to possibly strong gravitational stress, yet be amenable to nonrelativistic analysis. Tidal effects on the atom have been explored by perturbation methods and have been found to lead to a coupling of the 1s to higher order states. The resulting probability distribution is analogous to the classical distortion of a spherical water droplet subjected to tidal stresses.

DENSITY-FUNCTIONAL STUDIES OF CIS- AND TRANS- CONFORMATION OF PEROXYNITRITE ANION ( $-OONO$ ) AND ACID ( $HOONO$ ). Shigang Zhang and J.G.Harrison, Department of Physics, University of Alabama at Birmingham, Birmingham, AL 35294.

We have performed first-principle calculations for peroxyxynitrite anion ( $-OONO$ ) and acid ( $HOONO$ ) within the local spin density approximation of Density Functional Theory as part of an effort to understand their role in tissue damage associated with various disease states. We find that for Gaussian-88 optimized geometries the Cis-conformation for both anion and acid are respectively lower in energy than those of trans- by about 4.70kcal/mol and 3.21 kcal/mol.

MÖSSBAUER SPECTRUM OF  $Co^{2+}$ - $Ti^{4+}$  SUBSTITUTED BARIUM FERRITE  
Jenny O. Hai, David G. Agresti, Department of Physics, University of Alabama at Birmingham, Birmingham, AL 35294

Mössbauer spectroscopy was employed at room temperature to observe the effect of cobalt and titanium substitution on barium ferrite magnetic material. A series of substituted barium ferrite samples ( $BaFe_{12-2x}Co_xTi_xO_{19}$ ) where x ranges from 0.0 to 0.9 were studied.\* Examination of the spectra indicates peak broadening along with increasing dopant. This results in failure to fit a 5-site model when x is greater than 0.6. It is evident that occupation of 12k site increases with x, and the analysis shows that the hyperfine field decreases linearly for all 5 sites.

\* Samples were supplied by Y.K.Hong, B.J.Chung, etc., Oriental Chemical Industry



A Fixed Target Experiment at the SSC. Charles Merrill Jenkins, Department of Physics, University of South Alabama, Mobile, AL 36688.

The Superconducting Super Collider (SSC) is expected to be constructed and taking data by the year 2000. The well publicized experiments are collider types of experiments where the counter circulating beams are focus onto a small area where the protons will collide head on for the maximum center of mass energy. A little publicized experiment (EOI-14) will use a fixed target configuration where a single 20 TeV proton beam will be extracted from the accelerator and directed onto a fixed metal target. The beam extraction method must be compatible with operating the accelerator in the colliding mode. Currently, the front running method is crystal extraction. The 20 TeV beam will be directed to a spectrometer similar in configuration to other fixed target spectrometers used today at Fermilab. This experiment will study the production of B mesons, and various decay properties including: lifetimes of individual B meson species, B and anti B meson mixing, observation of rare B decay modes, and possibly CP violation. The talk will discuss the extraction method and outline the spectrometer components and configuration. In addition, methods of detecting CP violation in the B system will be discussed.

DESIGN AND OPTIMIZATION TECHNIQUE FOR THREE-MIRROR PROJECTION LITHOGRAPHY. Cheng Wang, David L. Shealy, Dept. of Physics, Univ. of Ala. at Birmingham, Birmingham, AL 35294.

Based on Korsch's method for design of telescope systems, a differential equation method for design of three-mirror systems for X-ray projection lithography has been developed. By applying this method to a Canon projection lithography system, we have demonstrated that differential equation method is an effective way to design and optimize three-mirror optical systems. Some analysis data of the performance of the optimized system will be presented compared with the original system.

#### ACKNOWLEDGEMENT

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FOURIER SERIES AS APPLIED TO HOLOGRAPHY. Mary E. Swigert, MCIS Dept., Jacksonville State Univ., Jacksonville, AL 36265.

Two sections will be discussed; the first involves the history and definition of holography, and the second involves a physical and mathematical analysis of holography using Fourier Analysis. Various applications of holography will be discussed. Acknowledgement of support is given to Dr. John Van Cleave, Mr. Clarence Angelette, and Dr. Bill Reid for technical assistance.

## Abstracts

A TRANSIENT FORM OF OHM'S LAW WITH APPLICATIONS. John H. Young, University of Alabama at Birmingham.

The application of Ohm's law,  $J = \sigma E$ , to describe charge motion in response to electric fields varying over extremely short time scales can be seen to lead to unphysical results. The origin of this difficulty is rooted in the implicit assumption of Ohm's law that a "steady state" charge motion is in effect, thus ignoring transient behavior completely. A modified form of Ohm's law which takes into account transient responses will be presented and illustrated by application. The modification would appear to lead to a more comprehensive and satisfactory description of charge motion through transient periods and on into the stabilized conditions assumed by Ohm's law.

ANTENNA, A HIGH FREQUENCY LOOP. Paul D. Carr, Dept. of Science, Math, and Engineering, Gadsden State Community College, Gadsden, AL 35902.

How to combine two established antenna techniques and provide a low angle radiator for the high frequency spectrum.

## INDUSTRY AND ECONOMICS

REQUIEM FOR INNOVATIVE HOTSPOTS IN ALABAMA. Paul Herbig and Jim Golden, Department of Marketing and Management, College of Commerce and Business Administration, Jacksonville State University, Jacksonville, AL 36265

Why has High-Tech Innovation flourished in some regions of the United States (Route 128, Silicon Valley) but not in others (West Virginia, Montana)? Why are other areas of the US beginning to blossom in much the same and will likely become Innovative HotSpots of the 1990's (Austin, TX; North Carolina Research Triangle)? What are the factors that are required for Innovative HotSpots to occur?

We examine these factors from an analysis of Route 128 and Silicon Valley as well as the "baby" HotSpots in process. We then look at Alabama from each of the determined factors, compare versus what exists today and planned for the near future, and present recommendations if Alabama desires to have an Innovative HotSpot in this state.



LEADER IMPACT ON ORGANIZATIONAL EFFECTIVENESS. W. Mark Hearn and Darryel Roberds, Dept. of Management, Jacksonville State Univ., Jacksonville, AL 36265.

Debate surrounding the impact that a leader has on overall organizational effectiveness and what definitions of effectiveness to use in assessing this impact continues. Definitions generally consider the extent of goal accomplishment, the ability to obtain needed resources, the efficiency of internal processes and procedures, or the degree to which various constituencies' needs are met. While no one definition is appropriate for all organizations, organizational activities generally delineate the investigative model. Furthermore, while available evidence suggests that major decision makers should be the source of criteria used in assessing the interrelationships between the organization's functional and environmental uniqueness and overall effectiveness, little empirical research in this area has been published. The literature surrounding leader impact on organizational effectiveness tends to support the proposition that leader attitudes have causal priority over behaviors and thus effectiveness. It follows, then, that a leader's attitudes affect the relationship between his/her personality and strategic decision making. If these attitudes can be identified, this criteria could be used to more accurately reflect an individual leader's role in organization performance as well as allow for increased empirical precision in leader impact comparisons. This suggests that valid and reliable measurements of leader attitude and personality could be highly predictive of organizational effectiveness.

A COMPARATIVE ADVERTISING RISK CONTINUUM: IMPLICATIONS FOR MARKETING STRATEGY. Donald W. Caudill, Assistant Professor of Marketing, Southern Arkansas University, Magnolia, AR 71753

Comparative advertising became legitimate and popular in 1972 when the Federal Trade Commission began advocating its use by holding that the naming of a competitor's brand would not be considered unfair competition (today nearly 40 percent of all television advertisements are comparative; before 1973 they were banned by all three major networks). Although virtually twenty years has passed, very little empirical or theoretical research has been done on this topic. A review of the literature revealed that no research had been done on "risk" associated with comparative advertising. Any comparison can be risky (the leader in the field should not start a comparative campaign because they have little to gain). This study focused on the degree of risk (low, medium, high) connected with the various kinds of comparative advertisements. Seventeen comparative formats were ranked on a risk continuum (i.e., referring to the competition as "Brand A" is substantially less risky than a same-size package side-by-side comparison because the named competitor may benefit as much or more).



## Abstracts

WHEEL OF MANAGEMENT PHILOSOPHY. Leon L. Smith, Dept. of Marketing and Management, University of North Alabama, Florence, AL 35632.

Managers and others interested in organizational behavior have, over many years, attempted to assess the degrees of effectiveness and efficiency resulting from various management 'styles' or philosophies. The procedures of management, which can be termed *modus operandi*, appear to have predictable outcomes profoundly influencing the overall success criteria of reaching goals using optimum resources. Basically these outcomes can be summarized by three culminations: compliance, resistance, and commitment. Because it is difficult, if not impossible, to correlate productivity with an organizational member's sense of satisfaction, it is useful to at least infer that commitment as an outcome is more desirable than compliance and resistance. *Modus operandi* can vary greatly within any given organization and between organizational units. Therefore, it is important to note that the perception of operant management philosophy is generalized by organizational members resulting in a dominant 'theme' which is usually labeled. The resultant transformation of various philosophies can be understood best by a 'wheel' graphic depicting dominant *modus operandi*, elements of implementation, and the three principle outcomes described above. Starting at the top of the wheel in the compliance outcome 'third', tyranny (*modus operandi*) uses martial law (element of implementation) to produce the outcome (compliance). Continuing clockwise, dictatorship implements by edicts, autocratic control - rules, etc. Beginning commitment, habitual behavior implements by routine, consistent behavior - tradition, etc. Beginning resistance, divergent behavior implements by independence, dysfunctional behavior - clique formation, etc. Conclusions are drawn about wheel relationships including specific management techniques to facilitate implementation and commitment.

ANALYSIS OF JUST-IN-TIME MANUFACTURING SYSTEMS. Cara M. Beste, Troy State University in Montgomery, Montgomery, AL.

Manufacturing firms that adopt Just-In-Time Inventory Systems (JIT) seek to reduce their total production costs by minimizing the variable expenses incurred by handling warehouse and transactional costs involved with components, supplies, and raw materials used by the firm to produce the final product. JIT systems can improve production through a total system viewpoint and the integration of procedures and processes for the purpose of preventing waste and promoting efficiency. The positive result of this effort is a reduction in total costs of manufacturing and improved company profits by the reduction or elimination of certain types of overhead. This paper defines JIT, discusses the goals and philosophy of JIT, explains several advantages as well as disadvantages of JIT implementation, and explores the experiences of several firms currently using the JIT Manufacturing concept.

## Abstracts

PROTECTING PERSONAL ASSETS FROM LEGAL LIABILITY. Bill Scroggins and Bill Fielding, Finance Dept., JSU, Jacksonville, AL 36265.

The threat of being sued personally for malpractice or a negligent act has become a serious occupational hazard for corporate officers, directors and professionals of all types. Many professionals have questioned the adequacy of their liability insurance. They want to know how they can lawfully minimize the possibility of loss of home, retirement savings, and children's education funds to creditors of their business or profession. This paper discusses that unpleasant possibility and describes a number of techniques which can be utilized to protect family assets. A typical reaction of a debtor confronted with the claims of creditors is the conveyance of property to friends or relatives for little or no consideration. To remedy this situation, the Uniform Fraudulent Conveyance Act as well as the language of its new rival, the Uniform Fraudulent Transfer Act allows the plaintiff to bring action to "set the conveyance aside." Most states have laws which recognize the importance of the home to the well being of the family and seek to insulate it against most creditor claims. The most notable of these laws relate to the tenancy by the entirety and the homestead declaration. Alternative trust arrangements for protecting family assets include: trusts with spendthrift clauses, irrevocable trusts and reversionary trusts. The family home is generally the most important asset we own, but for self-employed persons, the retirement plan may be the largest single asset. Such plans are highly desirable because of their tax benefits and the fact that retirement funds are largely exempt from creditor claims under federal law. The status of tax qualified retirement plan trusts, keogh plans and IRAs are examined. The use of life insurance, filing for bankruptcy and professional incorporation are other techniques for avoiding creditor claims.

PRICHARD ALABAMA; PAST AND PRESENT :A Tale of Two Cities  
James E. Moore, Department of Community Planning  
Alabama A&M University, Normal, AL 35762

There is a vast difference between the Prichard of today and its early beginnings. This preliminary research is a historical analysis of the changing face of a once thriving city. Prichard is located in southwest Alabama in northern Mobile county. It was founded by Cleveland Prichard who was at one time called the "Vegetable King of America." Because of his efforts, Prichard became the nation's main port for transporting vegetables throughout the country. As a result of this industry, the city grew in population from 3,400 in 1930 to over 50,000 in 1960. It was once called the fastest growing city in the south. Now, it is a city of high unemployment, crime and has the distinguishing title of the poorest city of its size in the United States. A city that was once flourishing is now a poor desolate area. Amidst all of these problems there is a glimmer of hope in the fact that a new interstate highway will again expose this city to economic growth and prosperity.

## Abstracts

The Job Corps: Which Alabama Centers Benefit Alabamians the Most?  
Dennis W. Gibson, Troy State University in Montgomery, Montgomery, AL  
36103.

The Job Corps a residential manpower development program established by the Economic Opportunity Act of March 1964, celebrated its 25th anniversary in April, 1989. As with other current manpower development programs, its origin can be traced to the Civilian Conservation Corps and the Works Progress Administration of the "Great Depression" in the 1930s. The population used in this research consisted of 3,548 trainees from Alabama who terminated their training in program years 1983, 1984, and 1985. A random sample of 1,220 trainees was extracted from this number and included 908 completers and 312 noncompleters. The U.S. Department of Labor records were matched with the Employer Unemployment Compensation Wage Reports maintained by the State of Alabama, Department of Industrial Relations. This research found positive earnings effects for trainees who complete the Job Corps program as reported by this author at the 1990 Academy meeting. An analysis of the effectiveness of individual Job Corps Centers was undertaken this year. Thirty-eight centers hosted Alabama trainees The Tuskegee, AL, and E.C. Clements, KY centers had significantly higher retention rates and post-training individual earnings. The Oconaluftee, NC, Turner, GA, Brunswick, GA, Batesville, MS and Knoxville, TN centers had significantly lower retention rates and post-training individual earnings. The policy implications of this finding should revolve around sending future trainees from Alabama to the centers that can provide the greatest benefit to the trainee.

The Educational and Economic Impact of a State-Wide Industrial Internship Program for Science and Math Teachers. Brinda P. Lisano and Bettie B. Burkhalter, Economic Development Institute, Auburn University, Alabama, 36849-5252.

Education and industry -- how important is the linkage? If America's capacity to compete in the global market is to improve, so must education: particularly science and math. Without a long-term investment in education the quality of the work force will fail, thus having a direct impact on the economy. The Auburn University Economic Development Institute and the State of Alabama recognized the importance of this linkage and the direct impact it would have on improving the capacity of the United States to regain the competitive edge in the global market. The Governor's Industry Internship Award was designed to place quality science and math teachers into selected industries for six weeks. During that time the teacher interns observed, participated in daily application of job skills, and identified how science and math skills were applied on a daily basis in today's work force. The teachers transferred knowledge from the internship into the classroom curriculum through learning activities. It is this type of linkage between education and industry that can make a difference.



## Abstracts

ECONOMIC IMPACT OF ALABAMA'S RETIRED MILITARY OFFICERS. Louise J. Clark, College of Commerce and Business Administration, Jacksonville State University, Jacksonville, AL 36265

A study was conducted to investigate the economic impact of retired military officers on the State of Alabama. A total of 680 surveyed retirees was selected from a list of 6500 State military retired officers furnished by The Retired Officers Association. The majority retired from the Army at the rank of Lt. Colonel. Most have spent at least 10 years of retirement in Alabama; few plan to leave. Many retired in the State either because it is their home, they have relatives in the State, or they were stationed in Alabama while on active duty. Retirees spend time dining out, traveling, participating in sports, and gardening. The majority own a home; the average appraised value is \$91,193 and half are mortgage free. Many own other property in the State as well. Retirees have an average of 2 vehicles, most of which were purchased in Alabama. Over 80% have sources of income in addition to retirement. Almost the same number have financial or business investments. Retirees spend for groceries, housing, clothes, entertainment, healthcare, and hobbies. The majority of purchases are made at local stores; however, one-third shop predominately on military bases. Two-thirds are aware of the State's efforts to attract retirees. However, they feel that to maximize this effort, improvements are needed in State government, education, roads and highways, cultural and recreational events, medical facilities, and transportation. Over 44% indicated that they would vote in favor of a 10% increase in property taxes to support education. The typical retiree is between the ages of 60 and 70, is married with no children living at home, retired with 20 to 25 years of service, and has a median annual family income of \$44,925.

PATIENT SATISFACTION EFFECTS ON POST-ENCOUNTER WORD-OF-MOUTH IN A MILITARY HEALTH CARE SETTING. William F. Koehler, Dept. of Marketing, Jacksonville State University, Jacksonville, AL 36265.

As part of a larger study, this research explored the effects of patient satisfaction on the post-encounter Word-of-Mouth (WOM) of 298 patients in an Army hospital. Theoretically, public complaining and the frequency of negative WOM should be negatively related to satisfaction. The frequency of use of a particular hospital and positive WOM should be positively related.

As expected, both public action in complaining and the frequency of patient negative WOM were negatively related to satisfaction. Satisfaction was positively related to positive WOM. Finally, the frequency of patient use of the military hospital had no effect on their positive WOM. This result rejected the theoretical hypothesis.

Qualitatively, the patients were quite vocal about their health care, and the principal participants in WOM were spouses, friends, and family members. Sixty-four percent participated in three or more conversations about recent care, and 30% had more than five conversations. There was one principal "giver" of information: the respondent's spouse. The spouse was perceived to be knowledgeable by 35% of the sample, 39% said no one, and about 15% indicated a friend or military associate.

## Abstracts

WHEEL OF MANAGEMENT PHILOSOPHY. Leon L. Smith, Dept. of Marketing and Management, University of North Alabama, Florence, AL 35632.

Managers and others interested in organizational behavior have, over many years, attempted to assess the degrees of effectiveness and efficiency resulting from various management 'styles' or philosophies. The procedures of management, which can be termed *modus operandi*, appear to have predictable outcomes profoundly influencing the overall success criteria of reaching goals using optimum resources. Basically these outcomes can be summarized by three culminations: compliance, resistance, and commitment. Because it is difficult, if not impossible, to correlate productivity with an organizational member's sense of satisfaction, it is useful to at least infer that commitment as an outcome is more desirable than compliance and resistance. *Modus operandi* can vary greatly within any given organization and between organizational units. Therefore, it is important to note that the perception of operant management philosophy is generalized by organizational members resulting in a dominant 'theme' which is usually labeled. The resultant transformation of various philosophies can be understood best by a 'wheel' graphic depicting dominant *modus operandi*, elements of implementation, and the three principle outcomes described above. Starting at the top of the wheel in the compliance outcome 'third', tyranny (*modus operandi*) uses martial law (element of implementation) to produce the outcome (compliance). Continuing clockwise, dictatorship implements by edicts, autocratic control - rules, etc. Beginning commitment, habitual behavior implements by routine, consistent behavior - tradition, etc. Beginning resistance, divergent behavior implements by independence, dysfunctional behavior - clique formation, etc. Conclusions are drawn about wheel relationships including specific management techniques to facilitate implementation and commitment.

Foreign Investment in the United States. Harry M. Joiner, Social Science Department, Athens State College, Athens, AL 35611

After World War II, the United States became the world's most important foreign investor. However, since 1985, foreign investment in the United States has exceeded the outflow of dollars abroad. Foreign interests have put more than a trillion dollars into the American economy. The most important investment sectors are business (\$328 billion), U.S. government debt (\$240 billion), stocks (\$200 billion), corporate bonds (\$160 billion), and real estate (\$65 billion). In 1988, foreign investments in the U.S. exceeded total U.S. investments abroad by \$577 million. Foreign investors now own some of the nation's largest corporations, such as Standard Oil of Ohio, Firestone Tires, Pillsbury, Carnation, and MCA. The trend of foreign investment is towards acquisitions rather than the establishment of new businesses. At present, most economists, politicians, and businessmen believe that foreign investment is good for the country. Foreign investors do not dominate any business sector, and their holdings account for only 3 percent of the nation's wealth. By comparison, foreign investors own about a third of Canada's industrial assets. As the pace of foreign investment increases, Americans might decide in the future to take a closer look at the advantages of foreign investment.



## Abstracts

SOME PRELIMINARY FINDINGS REGARDING PROSPECTS FOR A MINORITY BANK IN HUNTSVILLE, ALABAMA. Marsha D. Griffin, Dept. of Mkt., AL A&M Univ., Normal, AL 35762. James G. Alexander, Department of Eco. and Fin., AL A&M Univ., Normal, AL 35762.

In early 1990, a group of prominent Black business leaders, working with a regional minority bank, approached Alabama A&M University to ask for a feasibility study for a minority bank in Huntsville, AL. Interest in establishment of a Black bank is based on perceived community need for improved financial services. This paper presents one underpinning of that study: a survey of attitudes of Black business people and Black consumers regarding a minority owned/managed bank. During the spring of 1990, questionnaires were administered to 57 Black business leaders and 59 Black consumers in the Huntsville area. Looking at the Black business community, 75% indicated they would move at least part of their banking business to a competitive, well-known minority bank. When asked if they would support a new minority bank (not a branch of an existing bank), 56% said yes. Sixty percent indicated they would support a minority managed "white" bank constructed in a predominantly Black neighborhood. In order to test the allegiance of Blacks, they were asked if they would support a minority bank if its fees were higher than average; only 16% said yes. From the Black consumer viewpoint, 86% indicated they would patronize a competitive branch of a well-known minority bank. Forty-nine percent said they would support a newly chartered minority bank. Sixty-nine percent said they would patronize a minority managed "white" bank in their neighborhood. Only 22% would patronize a minority bank if its fees were on the high side.

SIMULATION BASED MICRO COMPUTER MODELS FOR AUTOMATED COMMUNICATIONS NETWORK DESIGN.  
Richard Cobb, Management Department,  
Jacksonville State University, Jacksonville,  
Alabama 36265.

Automated communications networks are complex structures with many variables which influence system performance. The purpose of this research was to develop a micro computer model that can be used to help design such networks. The micro computer model was developed using simulation data based on a broad range of network designs. The data was then used to analyze the effects of various design variables. These variable effects were then included in a more usable form in the micro computer model. The resulting model offers designers a simplified tool useful in estimating transmission delay in an automated communications network.



## Abstracts

**EMPLOYEE PERCEPTIONS OF ORGANIZATIONAL EFFECTIVENESS RELATIVE TO THE USE OF WORK GROUP MEETINGS TO SOLVE PROBLEMS.** Bruce T. Durham, Dept. of Business, Troy State Univ. in Montgomery, Ala., AL 36013

American businesses have begun to institutionalize participative management systems as part of a process to improve productivity among employees and provide companies with a competitive edge in the world markets. Although many firms have experimented with various participative management approaches over the past 30 years, only recently has the notion of work group empowerment taken root as an operational necessity. This study is an exploration of the perceptions of employees who use processes associated with empowerment in performing their jobs relative to those who use traditional approaches to solving problems and setting priorities. The subject of this study was CNRD Inc., an Alabama electronics manufacturer. Using an organizational assessment instrument, on-site interviews, observations, productivity data, and the Statistical Package for the Social Sciences, data were collected, analyzed and processed. The body of literature suggested that workers who used empowerment processes would have more positive perceptions of organizational effectiveness than those who did not. Further, these perceptions could influence employee behavior, thus causing this group to perform better than the other group.

**CORPORATE HEALTH AND WELLNESS PROGRAM UPDATE.** Patricia C. Borstorff. Department of Management and Marketing, Jacksonville State University, Jacksonville, AL 36265.

Wellness programs are often a response to astronomical national health care costs, which the U.S. Department of Health and Human Services (HHC) forecasts being \$1.5 trillion annually by the year 2000. With medical and hospital benefits showing approximately a 20 percent annual increase for employers, corporations are looking at wellness programs in a new light. Companies today can learn from the successes and failures of the past two decades and improve their chances of a successful program by following some specific guidelines. These include top management commitment, a mission and goals showing the organization's support for the program, employee input, a wellness specialist, and incentives for those participating in the program. While programs are being enlarged and refined, a debate continues over the cost-benefits of the programs. Some of the larger corporations offer proof of savings from two to eight dollars per dollar invested. Other people cast doubt on the savings from wellness programs, the positive effect on employees' lives, and the ability of even reaching the high risk workers. Important considerations for wellness programs of the 1990s include employees' attitudes, motivation, and participation and the larger issue of liability. Currently, research is substantial on the employee issue; however, research on the liability issue is limited.

THE CHALLENGE TO ALABAMA'S SYSTEM OF SCHOOL FINANCE. James G. Alexander, Dept. of Eco. and Fin., AL A&M Univ., Normal, AL 35762.  
Marsha D. Griffin, Dept. of Mkt., AL A&M Univ., Normal, AL 35762.

Alabama is currently confronted with a challenge to its system of school finance which it ignores at its own peril. Broadly, there are three key elements to this challenge: 1) interdistrict funding equity or equality of educational opportunity; 2) adequacy of financial support; and 3) tax structure and tax burden distribution in support of education. The first element is of special interest because it is the basis for the present legal challenge to Alabama's school funding system. Alabama Coalition for Equity et al vs. Guy Hunt et al centers on the equal protection provisions of both the U.S. and Alabama Constitutions. Plaintiffs in this case, which include 14 school districts, charge that the state's method of allocating funds among school districts--and thus among the state's children--irrationally and arbitrarily discriminates to the disadvantage of poor districts. While this issue has not yet risen to a high level of public discussion, there is ample reason to take the challenge seriously. In recognition of the merits of the challenge, several nominal defendants have sided with the plaintiffs. Also, experience in other states which have confronted similar legal challenges suggests that the suit should not be dismissed as inconsequential. Moreover, Alabama's future economic competitiveness is likely to depend on how the school funding issue is resolved. This study addresses the nature of the equity/opportunity challenge, the Alabama school finance situation, and possible avenues of remedy.

A RECONSIDERATION OF THE EFFECT OF WALL STREET WEEK INFORMATION ON STOCK PRICES. Bruce Jones, Barry Morris and Bruce Gordon, University of North Alabama, Florence, AL 35632-0001.

Some people study finance and investments with the objective of finding some method of earning a superior rate of return on their portfolios. The efficient market hypothesis suggests that there exists no method or strategy that will consistently "beat the market." Many investment strategies have been subjected to empirical testing. The results of most research supports the semi-strong form of the efficient market hypothesis. In spite of this body of evidence in support of the EMH, many individuals earn a living providing information to investors in search of superior returns. A case in point is Louis Rukeyser and his program "Wall Street Week" which airs every Friday evening on PBS. The purpose of this paper is to determine whether an investor could develop a market-beating strategy based on the recommendations of these experts. Most empirical research has focused on analysis of the residuals left after estimating the security market line. The authors argue that such a procedure is unduly complex. Borrowing a technique from forecasting the authors treat the new information as a seasonal variable. The authors present evidence that this simpler procedure yields similar results. The analysis of findings are more straight forward and comprehensible to practitioners.

## Abstracts

HUMAN RESOURCE MANAGEMENT PRACTICES IN SMALL ALABAMA MANUFACTURERS. Robert D. Gulbro, Department of Management, Jacksonville State University, Jacksonville, AL 36265.

The purpose of this research was to test the hypothesis that a relationship exists between the Human Resource Management practices of small Alabama manufacturing companies and the performance of their organizations. Data were obtained from 152 small independent manufacturing firms located throughout the state of Alabama. The owners of these firms responded to a mail questionnaire containing questions about their Human Resource Management practices. The owners rated the value of the contribution made by their Human Resource Management practices to the success of their firms. Responses were analyzed using analysis of variance tests and discriminant analysis. No significant relationship was found between any of the thirteen individual Human Resource Management practices and organizational performance. Sales per employee was the measure chosen for organizational performance. The perception of the value of the practices did increase with organizational size. Other factors may be more important to the small business owner than Human Resource Management.

COMPUTER USE BY CPAS IN ALABAMA, AN ANALYSIS. M. Parker Granger, Dept. of Accounting, Jacksonville State Univ., Jacksonville, AL 36265

Today's increasing use of microcomputers has moved the practicing accountant from experiencing an occasional contact with a large computer system to an everyday need of a microcomputer as a desktop tool. This study was conducted by sending a questionnaire to 749 CPA firms in Alabama to determine the type and amount of computer applications currently being used. The 22.8% response level was a cross-sectional response comparing to the distribution of firms by size and type.

The study found that the respondents provided a variety of services in which they used computer tools. The large majority of the firms used IBM or IBM compatible desktop equipment. The firms were almost evenly divided between those who designated computer work to specific individuals and those who expected all employees to be proficient with computers. The firms used a variety of software brands and most had an expectancy that their employees be able to do more than create basic applications. In those firms that used audit software, the expected proficiency in use of audit software was greater than that for other software. The most commonly used software were: Spreadsheet - Lotus; Database - dBase; Integrated Accounting Programs - Peachtree; General Ledger Application - Creative Solutions; Audit Programs - Fast; Tax - 1040 Solutions; and Word Processing - Word-perfect.



## Abstracts

MARKETING STRUCTURE OF THE LANDSCAPING PLANT INDUSTRY. Veronica Free, Dept. of Economics/Finance, Univ. of North Ala., Florence, AL 35632-0001.

The landscape industry exerts a great economic influence in the United States agriculture. According to a Southern Regional Research Project, commercial nurserymen in the United States rose from \$280 million in 1969 to \$1.16 billion in 1982, or an increase of 414%. Acreages of commercial nursery crops rose substantially in the United States and in the South. Continued growth of the commercial landscaping industry is the result of many factors: increased personal income, rising housing starts, increased gasoline prices which contribute to more time spent at home, increased prices in other recreational endeavors, increased use of landscaping in commercial business operations, increased awareness of concern for the environment. The relative importance of the South in the national landscaping industry is increasing. In 1982, the 13 Southern States accounted for approximately 29% of the U.S. total sales of nursery stock. Some of the factors contributing to the growth of the Southern landscaping industry are favorable climate and lower production costs. Of course, these favorable factors are somewhat offset by increased costs of transportation. Other favorable factors for the nursery and landscaping industry is the decline of traditional agriculture and the desire of farmers for an alternative crop. Further research is needed to determine the future potential of the Southern industry to provide jobs and commercial opportunities vis a vis the growth in other regions.

CONFLICT RESOLUTION STYLES OF A SAMPLE OF ALABAMA MANAGERS. Kerry P. Gatlin and Keith Absher, Department of Management and Marketing, University of North Alabama, Florence, AL 35632

The Thomas-Kilmann Conflict Mode Instrument was used to sample a group of one hundred and two supervisory level managers in the Florence area. The resulting conflict resolution style profile developed for these managers was compared with a control group of three hundred thirty nine practicing managers from throughout the United States.

The Alabama managers were found to rely on a competing style less frequently than the national control group; to use a collaborating or problem-solving style significantly more often; to avoid conflict more frequently and to use an accommodating style more frequently. No difference was found between Alabama managers and the national control group in the use of a compromising style.

The conflict resolution style survey was extended to include management students at the University of North Alabama. In general, students differed more dramatically from the control group of national managers than did the sample of practicing Alabama managers. The findings suggest a need for additional training in conflict resolution, particularly for students.

## Abstracts

INSIDER TRADING: RECENT EVIDENCE. Doris Bennett and George Trivoli, Department of Finance, Economics, and Statistics, Jacksonville State University, Jacksonville, AL 36265.

According to the strong-form of the efficient market hypothesis, current stock prices reflect all relevant information, regardless of whether the information is available to the public or privately held. If capital markets are strong-form efficient, then trading based on inside information should not produce excess profits. Most previous research found that insiders did earn excess profits in trading which occurred between 1960 and 1980. This research develops methodology to test the strong-form of the efficient market hypothesis by investigating two aspects of insider trading for a more recent time period, 1982 through 1990. First, returns to insiders for 6, 12, 24, and 36 month holding periods will be compared to market returns for the same time periods to determine if insiders did earn excess returns during the 1980's. Second, transactions of different categories of insiders (officers, directors, and large shareholders) will be tested for differences in profitability. If trading using private information is more profitable, officers, who would have earlier and easier access to the information, should earn higher returns than directors and shareholders. The existence of abnormal profits for all insiders as a group or for any of the three categories individually implies that the market is not strong-form efficient.

INVESTIGATION OF A FIRM'S CREDIBILITY AND REPUTATION AS INTEGRAL ELEMENTS OF CORPORATE STRATEGY. John Milewicz and Paul Herbig, both of the Dept. of Marketing and Management, Jacksonville State University, Jacksonville, AL 36265

The purpose of this study is to quantitatively measure the impact of certain business decisions on the decision making firm's reputation and credibility. Reputation is defined as the estimation of the consistency over time of an attribute of the firm. Credibility is the believability of a firm's intentions at a particular moment in time. The study was implemented through a simulation of business pricing activity using MBA students and advanced undergraduates as the decision makers. The starting point of analysis was the "credibility transaction" defined as the interpretation by a competitor of a marketing pricing signal by the decision making firm. Results of the study demonstrated that a firm's reputation is the results of successive credibility transaction (CT), not just the latest CT. Once discontinuity appears and is reinforced by sometimes true and sometimes false signals (mixed signals) reputation suffers quickly and dramatically. The same perspective applies to credibility. Once reputation is destroyed by mixed signaling the research found it takes 3 to 5 times the application of consistency (true signals) to restore reputation. Thus, consistency in marketing signals is essential to maintain a firm's standing in the marketplace.

RETAIL SALESPERSONS AND CONSUMER ATTITUDES: AN ANALYSIS BASED ON RACE AND SEX. Donna Yancy and Keith Absher, University of North Alabama, Florence, AL 35632-0001.

Consumer attitudes are formed about retailers through many elements. These elements would include such factors as: price, location of store, types of displays, architecture, sales promotions, pictures, color schemes, inventory composition, advertising and sales personnel. The characteristics of sales personnel do as much as, if not more than, anything else to build and maintain the store's image. All shoppers have expectations and exhibit preferences for certain salespeople. If only a small percentage of salespeople fail to attract customers and meet expectations, much harm can be done in retail sales. The objectives of this report are (1) to measure consumers' attitudes towards retail salespersons based on race and sex of the consumers and the salespersons, (2) to provide data and research into this field for further study, and (3) to test power, competence, trust, and likability of the salespersons. An ongoing concern of the retailer is the attitude that their customers have towards salespersons.

AUCTIONS AND RUBLE CONVERTIBILITY. Cynthia McCarty, Economics Department, Jacksonville State University, Jacksonville, AL 36265.

Mikhail Gorbachev has declared that the Soviet Union will achieve ruble convertibility in East-West trade before the year 2000. As documented in the February 1990 Central Committee meetings, the role of ruble convertibility is to maintain the Soviet's strongly centralized, non-consumer sovereign economy, while enhancing the performance of the trade sector. Supporting the view that partial ruble convertibility can not only be theoretically achieved, but can also improve the efficiency of East-West trade when selected enterprise managers have the ability to purchase foreign inputs, this paper explores the feasibility and efficiency gains of introducing currency auctions into the existing Soviet system. Under such a regime the central bank regularly sells a given amount of foreign exchange through a bidding process and buys foreign exchange in the intervening period at the previously set auction rate. First, a microeconomic study of competitive exchange auctions with the assumption that no collusion exists between the bidders is examined. Second, collusion behavior is introduced and analyzed to determine its impact upon the auction's efficiency. An examination of potential counter-measures available to the central authorities is then discussed.



## Abstracts

### SMALL SERVICE BUSINESSES: FORECASTING ACCOUNTING PROBLEMS.

Angela H. Bell, Dept. of Accounting, Jacksonville State Univ., Jacksonville, AL 36265.

Small service businesses are facing a multitude of problems. Many must struggle to stay afloat given the complex and competitive environment in which they operate. These entrepreneurs need a method of forecasting, so they will be equipped to prepare for problems before they occur.

Like human beings have, successful small service businesses have a life cycle. They pass through their childhood years, grow into adulthood, become senior citizens, and finally experience death. Just as individuals find themselves faced with a wide variety of problems through their life spans, businesses also experience a diversity of problems.

The objective of this study was to explore the relationship between a small service business's stage of development and the accounting problems it experiences. The purpose was to discover if a common set of accounting problems exists for service firms in a similar stage of development.

### INTEREST RATE PROJECTIONS FOR THE 1990'S. Macon Wilbourn,

Dept. of Accounting and Finance, Auburn University at Montgomery, Montgomery, AL 36193.

War in the Persian Gulf has propelled current stock market averages to near-record highs while oil prices have plunged to pre-August lows. These events are occurring in the face of an economic recession that many economists fear will be severe by modern standards. As expected, the Federal Reserve has acted successfully to reduce interest rates with the prime now standing at 9%. Further declines in this benchmark rate are widely anticipated. But how will interest rates behave when economic growth ultimately begins to accelerate? Numerous considerations suggest that the price of credit is likely to remain above historic norms throughout much of the 1990's.

SCIENCE EDUCATION

DEVELOPING NATURAL RESOURCE SCIENCE LESSONS FOR CLASSROOM USE. Dennis W. Sunal, The University of Alabama, BOX 870231, Tuscaloosa, AL 35487

Planned curriculum development needs to occur if both the science content learned and the thinking skills used are to be meaningful. A curriculum development process for new science lessons or modules can be performed which demonstrates a practical process accessible to classroom teachers and small local curriculum projects. The process is aimed at development of meaningful learning, understanding the lesson outcomes and ability to apply them in other situations, as opposed to rote memorization of terms and answers to questions. Originating from three frameworks (information - processing, cognitive structure, and developmental theory) objects, events and experiences in the environment can be selected, sequenced, and presented to create exemplary natural resource science learning experiences for pupils. Four stages of the curriculum development process include: the research stage, the sorting stage, the activity development stage, and the lesson writing stage.

Using this focus the Natural Resource Science Curriculum Project will be described. It involves the interrelationships of human needs with biological and environmental resources. The complete curriculum development process started with the assessment of science curricula in schools and the selection of key natural resource science concepts. This led to writing and revision of trial modules, trial evaluation of modules in classrooms, teacher education activities, establishment of a classroom network of users and the dissemination of the curriculum materials.

Middle School Science Teaching: A Proposal for Its Improvement. F. Neff Weber, Department of Physics, University of South Alabama, Mobile, Alabama 36688.

The literally hundreds of proposals to improve science teaching in middle schools (and higher) have in almost every case been a band-aide approach: workshops, equipment improvement etc., etc. All of these should be pursued in the short term, not because they in any way are a solution to the problem, but simply because they may provide some slight improvement. A real solution to the problem lies in targeting an entirely new population of persons to teach middle school (and higher): scientist students. This proposal seeks to recruit junior physics and chemistry majors, with a proven record of achievement in their majors, to be science teachers. It discusses how to do this; it discusses the fact openly that this will be expensive and gives estimates of the cost of this radical approach.

STUDY/DISCUSSION GROUPS INCORPORATING CRITICAL THINKING SKILLS TO ENHANCE LEARNING. Sue Robinson and Frank A. Romano, Dept. of Biology, Jacksonville State Univ., Jacksonville, AL 36265.

The concept of small group learning techniques (Thelen, 1960) and critical thinking skill development (Ennis, 1962) served as a framework to explore its impact upon student learning and attitudes. Fifty-four adult subjects, enrolled in a freshman biology class, were approached to ascertain 25 volunteers to participate in a traditional learning plus study/discussion group (TLT+Group), i.e., they attended 2 one hour study/discussion sessions a week. The remaining 29 subjects were grouped together as tradition learning only (TLTGroup), i.e., they only attended lecture. The purpose of this study was to determine if there is a difference in the average semester grade and attitudes of those in the TLTGroup or in TLT+Group. In addition, critical thinking skills were incorporated into both groups. Improvement of test scores was monitored during the semester as well as semester grades and attitudes were determined by two questionnaires. There was no significant difference in the average semester grade of either group or of improvement during the semester. However, questionnaire I revealed that the TLTGroup showed an increased interest (over the TLT+Group) in science and biology and they shared this interest with others. Questionnaire II revealed the TLT+Group had a marked attitudinal difference showing a more positive response in all areas surveyed.

USING AVIATION CONCEPTS AND ACTIVITIES AS MOTIVATORS FOR MIDDLE SCHOOL SCIENCE STUDENTS. Ernest D. Riggsby, Dept. of Curriculum and Instruction and Joseph D. George, Dept. of Clinical Studies, Columbus College, Columbus, GA 31993.

With both television and motion pictures depicting the glamour of aviation and "top guns," it was felt that a window was open to stimulate young students to think, read, and learn more about aviation than is often presented through the entertainment media. The program we are describing was prepared for ordinary middle school science students with a wide range of interests and abilities. The subject matter of the program was taken from FALCON FORCE, a middle school aerospace kit which is available through the Civil Air Patrol Bookstore, Maxwell AFB, Alabama and which was written by a nationally selected board of authors, of which Ernest Riggsby was a member.



## Abstracts

The Effects of Immediate Achievement and Retention of Middle School Students Involved in a Metric Unit Designed to Promote the Development of Estimating Skills. Michael L. Jones, Wake County School System, Raleigh, NC 28401. Robert E. Rowsey, Department of Curriculum and Teaching, Auburn University, AL 36849.

Three hundred ninety-seven seventh-grade students were studied to determine the effect on immediate achievement and retention of a unit designed to promote the development of estimating skills involved in metric measurement. The study involved five teachers with a total of 15 average-or advanced-level classes divided into the reference and treatment groups. A five-day metric unit was designed so that both groups received exactly the same instruction in metric length, mass, and capacity with the exception of the treatment group's participation in activities relating to the development of estimation skills. Data collected from the Metric Application Instrument and analyzed with analysis of covariance indicated that students in the experimental group did retain significantly more of their improved metric application skills than the students in the reference group. The analysis of the main effects of race, sex, and ability indicated that white students achieved significantly more than black students and that males achieved significantly more than females. Analysis of significant race/ability and sex/race interactions indicated that (a) white students in the advanced group attained significantly greater achievement in metric application skills than black students of equal status and (b) white males significantly retained their metric applications achievement when compared to black males or black or white females.

SCORES ON STANDARDIZED ENTRANCE EXAMS IN CHEMISTRY. A. Barry Cox, Fred A. Gant, A. L. Studdard and R. Earl Poore, Department of Chemistry, Jacksonville State University, Jacksonville, AL 36265.

The Chemistry Department at Jacksonville State University uses the Toledo Chemistry Placement Exam (TCPE) to advise freshman for placement in Chemistry 105, the first course in the chemistry sequence or Chemistry 101, remedial chemistry. Results of a recent study show a high correlation between scores made on the placement exam and grades made in Chemistry 105.

Our study shows that of the students who (1) scored less than 35 percentile on the placement exam only 0.7% made a C in the course, all others failed; (2) scored greater than 35 but less than 40 percentile only 4.7% made C; (3) scored less than 40 percentile 1.6% made B; (4) scored between 40 and 50 percentile only 5.5% made B.

In summary, our data substantiates the findings of (1) Hunter and (2) Krannich in that to be reasonably sure of making C or better in the 105 course, a student must score above 50 percentile on the placement exam. Our data further show that students who made A in the course had an average TCPE score of 70.7.

## Abstracts

THE AGE OF THE AUTOMATED LECTURE. Beth C. Rico, CIS Instructor and Dr. Marlon C. Rico, Professor of Marketing, University of North Alabama, Florence, AL 35632-001.

A 1982 study by Stewart, Rico, and Walker compared teaching methods used by education institutions to those used by business firms. The results of that study suggested that teaching methods in business firms were more advanced than in the education industry because of the more modern equipment used in their training programs.

Perhaps the time has come for the education institutions to take greater advantage of modern space-age technology as an alternate approach to the old in person classroom lecture. A video presentation prepared for a particular lecture topic that has been previewed and polished to perfection before showing to the student has a number of advantages. A prerecorded lecture can be a more concise and effective presentation and it could be viewed by the student at other than the regular class time.

The purpose of the present study is to review the literature for an indication of the degree to which education institutions are utilizing video and television technology as a student learning tool. Information will be presented on schools that are using this technology along with problems and benefits. High production cost and economical production methods are discussed.

One article gives examples of businesses that have invested in VIDEODISK training methods and predicts greater efficiency and time saving advantages. A major weakness of television as a teaching tool is the ability to provide feedback to the student.

SATELLITE RESOURCES FOR STUDENT ENRICHMENT AND STAFF DEVELOPMENT IN SCIENCE. Larry Rainey, Center for Communications and Educational Technology, University of Alabama, Tuscaloosa, AL 35487.

There is an increasing array of instructional resources available for science teachers and students, including live, interactive satellite broadcasts. Currently, the University of Alabama's Center for Communications and Educational Technology (CCET) offers a variety of instructional and enrichment programs for students and teachers across the state and nation. Key elements of the programs include live interactivity providing immediate feedback, integration of computer technology, remote filming and broadcast capability, and a variety of studio and editing enhancement features (e.g., graphics, microscope camera, slides, etc.). Plans for next year include opportunities for teachers to earn graduate credit as participants in the programs, and production of a new seventh grade science course based on the current recommendations of the National Science Foundation and the National Science Teachers Association for an integrated scope and sequence approach to science education.

## Abstracts

DNA Transformation of ESCHERICIA COLI: A Recommended Laboratory for Advanced Placement Biology. Nancy Earnest, BioPrep/Center for Communication and Educational Technology, Univ. of Ala., Tuscaloosa, AL 35487.

In response to the explosive growth of DNA science and the need for public awareness of recombinant DNA and molecular genetics, the Educational Testing Service now recommends a bacterial transformation lab in its Advanced Placement Biology lab syllabus. Transformation (the uptake and expression of DNA by a living cell) was first demonstrated by Frederick Griffiths in the 1920s. While natural transformation is a random and rather rare event, induced transformation can be readily achieved--even in high school laboratories. Eschericia coli cells subjected to ice cold calcium chloride are made competent for transformation; that is, they become capable of taking up foreign DNA and expressing it. A simple protocol in which competent E. coli cells are exposed to pAMP (plasmid DNA containing the gene for ampicillin resistance) and then grown in the presence of ampicillin will be demonstrated.

USING AVIATION CONCEPTS AS A BASIS FOR ENRICHMENT ACTIVITIES FOR MILDLY HANDICAPPED PUPILS IN THE MAINSTREAM. Joseph D. George, Dept. of Clinical Programs and Ernest D. Riggsby, Dept. of Curriculum and Instruction, Columbus College, Columbus, GA 31993.

Mildly handicapped students are motivated by "hands-on" experiences. Their study of aviation science can provide fertile ground for just such experiences. The teaching of basic reading, writing and arithmetic skills can be facilitated using the "whole language" approach associated with the construction of model aircraft and the use of semantic organizers to describe the operations inherent in its real counterpart.

SOME ASPECTS OF THE NATURAL HISTORY OF LITTLE RIVER. Catherine Cain and David Whetstone, Dept. of Biology, Jacksonville State University, Jacksonville, Alabama.

Little River, flowing along the top of Lookout Mountain in the Cumberland Plateau of northeast Alabama, provides several distinct habitats which support a flora containing numerous rare and interesting species. These habitats are: 1) The deep, sandy soils of the mouth of Little River Canyon, 2) The gravelly shallows and river's edges, 3) Pitcher plant bogs, 4) Deep ravines, and 5) flat rock outcrops. The flat rock outcrops are examined in great detail.



## Abstracts

SCIENCE EDUCATION USING LOCAL NATURAL HISTORY. Douglas J. Phillips, Alabama State Museum of Natural History, University of Alabama 35487.

An effective approach to science education is through the use of local natural surroundings - exploring the features of students' "own backyard", so to speak. The public television series "Discovering Alabama" has employed this approach since its beginning in 1986. The series of videos features important aspects of Alabama's natural environment and is available for school use. Also available are related supplementary materials and in-service assistance.

## SOCIAL SCIENCES

DOMESDAY BOOK IN HISTORY. Peter F. Barty, Dept. of History & Pol. Science, Univ. of Nth. Ala., Florence, AL 35632.

The nine hundredth anniversary of the Domesday Survey generated renewed interest in this project of the first Norman king of England. The Public Records Office in London arranged to celebrate the occasion by publishing a new, de lux version of the entire survey with an accompanying translation from the original Latin, plus a comprehensive index. This paper traces the history of the Domesday Book, its origins and composition, its uses in history, earlier attempts at publication, and the actions taken over the centuries to preserve the document.

NUCLEAR PROLIFERATION: THE NEXT SCARE? Konrad M. Kressley, Dept. of Political Science, University of South Alabama, Mobile, AL 36688

Even though superpower nuclear war appears ever less likely, the spread of nuclear weapons, particularly in the 3d World, is a frightening development. The following hypothesis is offered: Over time, nuclear weapons will lose their special nature among other weapons of mass destruction. This technology cannot be "disinvented," but will spread as it becomes simpler and more commonplace. Although some use of these weapons cannot be precluded in the future, this will not destroy the world and the environment. Finally, the major powers will continue to use their qualitative technological advantage to constrain minor nuclear powers.

## Abstracts

### AFROCENTRICISM: ITS ORIGINS AND FUNCTIONS IN TIME PERSPECTIVE.

Emmanuel Konde, Dept. of History, Tuskegee University, Tuskegee, AL 36088.

Afrocentricism is a term of recent coinage, but its roots are imbedded in the long history of people of African descent. Over time, Afrocentricity has been called by diverse names and expressed in different ways designed to meet the exigencies of the moment. These expressions can be reduced to two essential components: the "physical" and the "intellectual" resistance of Africans to domination by Europeans. This study endeavors a full treatment of that resistance. The methodological approach used is that of historical analysis, tracing the origins of that resistance and its development through time, to the events and ideas that have converged in what manifests itself in our time as the mosaic of an historical movement called Afrocentricism: African-centered thought, attitude, mannerism, the newly found confidence and pride of African people in the knowledge of their glorious heritage--so wantonly distorted by Western man. Afrocentricism is not an ideology or doctrine of racial supremacy. It is neither an attempt to separate Africans from other races. Afrocentricism is an historical movement whose primary aim is to break the barriers of time and space that separate African people, to rehabilitate, and to have Africans inculcate through learning, their rightful place in the history of humankind--far removed from the fiction that is currently being taught in schools, colleges, and universities. The significance of this study is that it contributes a broad perspective in which to understand the internal dynamic of Afrocentricity.

### FLYING TRAINS AND STREAMLINERS: TECHNOLOGY TRANSFER FROM GERMANY TO THE UNITED STATES IN THE 1920s AND 1930s. Alfred C. Mierzejewski, Dept. of History, Athens State College, Athens, AL 35611.

Between May 1933 and May 1934, the German National Railway, the Chicago, Burlington and Quincy and the Union Pacific all introduced highspeed passenger trains using similar advanced technologies. The paper describes the three vehicles and demonstrates that technologies developed in Germany were adapted by American designers to suit the different operating requirements and market conditions prevailing in their country. The paper also shows how American railroads incorporated styling ideas from the Neue Sachlichkeit and Art Deco schools to enhance the public appeal of their vehicles. explains how and why a technology transfer took place, in this case between economies and cultures functioning in dissimilar political environments.

## Abstracts

**SURVEY OF COMPUTER USE BY UNDERGRADUATE PROGRAMS IN PSYCHOLOGY IN SOUTHEASTERN STATES.** Richard A. Hudiburg and Bruce Sides, Dept. of Psychology, Univ. of North Alabama, Florence, AL. 35632-0001.

A survey of computer use in psychology programs was conducted in five southeastern states: Alabama, Florida, Georgia, Mississippi, and Tennessee. The survey was sent to 100 psychology programs and 56 (return rate 56%) were returned. The programs had a median of 4 full-time faculty members and a median of 90 psychology majors. The programs reported that 66.2% of the faculty actively used computers. The most common computer uses for faculty and students were word processing and statistics. A large majority (70.4%) of the programs required or recommended computer literacy. Microcomputers were most commonly used and valued in psychology courses requiring numerical manipulations. Some of the programs (32.1%) had psychology computer labs. The most commonly available microcomputer systems were IBM PC/PC compatible systems (60.8%), which is indicative of the increasing trend toward use of these systems over Apple II. There were a wide variety of software packages used by the psychology programs. Most of the programs received adequate institutional support for acquiring computer hardware and software.

**The More Things Change: Booker T. Washington and The New Black Nationalism.** Lawrence J. Hanks, Department of Political Science, Tuskegee University, Tuskegee, AL 36088.

The quest for black equality in America has been largely compromised of three components: the political, the social and the economic. After the granting of freedom, the establishment of citizenship, and the right to vote, the quest for black equity can be divided into three major periods: (1) The Booker T. Washington Era, 1880-1915, where the focus was on procuring economic power while mitigating the emphasis on political and social rights; (2) The Era of the NAACP and The Post WWII Civil Rights movement 1916-1968, where the primary focus was on procuring political and social rights; and (3) The Post WWII Civil Rights Movement Era, 1969 to the Present, where the focus is on developing greater economic power while continuing to enhance political power and social rights.

This paper analyzes the strategies and accomplishments of each period while focusing on leaders and organizations. This paper ultimately argues that the economic focus of the New Black Nationalism is essentially a return to the economic development strategy advocated by Booker T. Washington.



## Abstracts

THE OSTROM CONCEPTUAL FRAMEWORK: RECONCILING THE TOP-DOWN AND BOTTOM-UP APPROACHES TO IMPLEMENTATION RESEARCH. John C. Morris and Gloria C. Burch, Department of Political Science, Haley Center 7080, Auburn University, AL 36849-5208.

Given the ongoing debate in the current literature over the application of opposing models of the implementation process, we outline and discuss the major components of the top-down and bottom-up approaches to implementation, and discuss the major criticisms of each approach. In an attempt to reconcile many of these criticisms, we propose the use of Elinor Ostrom's institutional framework as a vehicle for conducting implementation research. We find that Ostrom's lack of preconceptions about the role of various actors within the implementation arena, coupled with an emphasis on both formal and informal rules to constrain action, serve to overcome many common criticisms of the two models. In addition, we note that institutional analysis may act to bridge a deeper set of ontological and methodological disputes between the top-down and bottom-up models. Finally, we offer a discussion of the Ostrom framework applied to an ongoing study of State Revolving Funds as an example of the utility of the institutional model in studies of the implementation of federal policy in the United States.

Teaching Ethics at the University Level Education.  
Frederick A. Viohl, University College, Troy State Univ., Troy, AL 36082

Ethical dilemmas arise in the practice of all professions - in medicine, law, journalism, teaching and engineering, to name just a few. While front page headlines have focused on insider trading scandals and, more recently, on the savings and loan fiasco, ethical dilemmas are clearly not limited to the corporate world. These days, the news is full of accounts of personal misconduct. All across America, schools have simply refused to take responsibility for the character of their students, that they "wash their hands of the teaching of virtue, doing little to create an environment that teaches individuals the importance of self discipline, obligation and civic participation." Many academicians believe that by the time students get to graduate school, their ethical mindsets are well developed; however, the experts feel strongly that institutions of higher learning must shoulder at least part of the responsibility in helping to produce responsible citizens and leaders, who are capable of upholding ethical standards of conduct within their communities. In summary, schools can not entrust the responsibility to teach ethical analysis to the ad hoc kind of discussion that comes up in class. Schools must try to enhance the ethical and humanistic behavior of their students.

## Abstracts

Dream Recall and Academic Performance. Rhonda Bryan and G. Dale Baskett, Dept. of Psychology, Tuskegee University, Tuskegee. AL 36088

The present study focused on the relationship between dream recall and academic performance by studying 29 students from an introductory psychology class. The students were asked to report frequency of dreaming, hours slept and hours studied the night before taking an examination. Three groups were formed based upon their reported frequency of dreaming and the data were subjected to a one-way analysis of covariance with prior academic performance in the course as a covariate. The analysis indicated that those students who remembered dreaming "a lot" performed significantly lower on the exam than did those who either didn't remember dreaming at all or dream "a little". No significant differences were observed for the three groups on either time slept, time studied, or prior examination performance. The findings were discussed in relationship to a lowered quality of sleep which frequent dreaming might indicate. This research was funded in part by the Tuskegee University Dana Research and Teaching Program.

COMPARATIVE ANALYSIS OF THREE DIVERSE UNIVERSITIES. Dr. Jennings Marshall, School of Business, Samford University, Birmingham, AL 35229. Melissa Rae Durrett, Samford University, Birmingham, AL 35229.

In the spring semester of 1990, three schools were surveyed for statistical purposes: Birmingham Southern, Samford University and the University of Alabama at Birmingham. The purpose of the survey was to gather information concerning the students, particularly their sex, age, major, gpa, drinking and smoking habits, religious practices and so forth. A total of two-hundred forty surveys were received. First the information was entered onto a Lotus spreadsheet and then transferred over to Explore where statistical tests were performed. The presentation contains four categories: Students, Alcohol, GPA and Religion, each containing informational summaries gathered from each school. I would personally like to express my appreciation to Dr. Jennings Marshall for offering his support and guidance throughout this endeavor.

The Work Ethic and the Consumer Ethic in Robert and Helen Lynd's Middletown (1929) and Daniel Bell's The Cultural and Contradictions of Capitalism (1976)  
John W. Powers, Dept. of History, University of North Alabama, Florence, Alabama, 35632-0001. The decline of the work ethic has been paralleled by the rise of the consumer ethic in American culture from the 1920s to the 1960s. Two important, though flawed, studies have attempted to account for these changes. These are classic and seminal studies. However, more precision and less morality are needed to study these changes in American culture. I wish to thank the University of North Alabama for a University Research Grant that reduced my teaching load and enabled me to pursue my research.

GROUP POWER. Roy M. Lechtreck. Dept. of Social Sciences, Univ. of Montevallo, Montevallo, AL 35115.

This essay begins with a short reminder of the role groups played in bringing Pres. Franklin Roosevelt to adopt his "New Deal." It then discusses five things which make a citizen group effective -- money, organization, overlapping membership, size, and enemies. The acronym is MOOSE. Such groups are quite compatible with representative democracy, although opposed by elites. The paper ends with a list of laws that need to be changed or enacted to allow citizens' groups to play their proper role in American politics.

#### HEALTH SCIENCES

ANGER IN ADOLESCENTS. Maxine B. Jones, RN, DSN; Mary Katherine Peacock, RN, MSN; Jan Christopher, RN, MSN; Univ. of Ala. School of Nursing, Birmingham, AL 35294-1210.

Eighty-five adolescents, ages 11-16, were surveyed about their recognition and expression of anger and their views about acceptable/unacceptable expressions of anger. Data analysis included frequency tabulations and one sample chi-square tests for specific variables of age, grade in school, gender, race and family composition. Results were: 1) most adolescents can recognize when they are angry; 2) most express their anger to siblings, mothers, and friends; 3) males expressed anger externally more frequently than females; 4) a greater number of blacks than whites reported that anger is not related to depression or suicide.



## Abstracts

THE FACTORS THAT INFLUENCE ADVERTISING IN THE PROVISION OF ALABAMA HEALTH CARE SERVICES. Carol B. Murphree and C. George Tulli, Jr., Capstone Medical Center, University of Alabama, Tuscaloosa, AL 35401

What, if any, similar characteristics seem to influence the amount of health care advertising in Alabama? To answer this question, in December 1990, 185 questionnaires were mailed to the majority of hospitals and Medical Group Association members of Alabama. Forty-four percent of the surveys were returned. Questions asked included categories such as organization type, community population, type of media and percentage of overall budget spent on advertising. Organization type included governmental hospitals, not-for-profit hospitals, for-profit hospitals, hospital-based ambulatory units, private medical groups, professional corporations, university groups and other ambulatory units. The size of community population ranged from 4,000 to 1,500,000 with a mean of 290,765. For this survey, percentages of those who reported using different media were: television -- 40%, newspaper -- 79%, radio -- 58%, direct mail -- 61%, billboards -- 32%, yellow pages -- 94%, and other -- 27%. Not-for-profit hospitals, for-profit hospitals, and hospital-based ambulatory units had a higher percentage of using television. Private medical groups and professional corporations reported the least amount of advertising in all categories. Fifty of the 81 returned surveys indicated that 0-1% of the overall budget was allocated for advertising purposes.

AIDS/HIV PREVENTION IN THE PHILIPPINES: ARGUMENTS FOR AN EPIDEMIOLOGICALLY BASED REORIENTATION. Donald J. Goodwin, UAB School of Public Health, Birmingham, AL 35294

Epidemiological analysis of Philippine national AIDS registry data characterized 154 cases of HIV infection and identified significant surveillance limitations during the 1985-1990 period. The findings resulted in major changes in the national AIDS/HIV profile and refuted the prevalent impression that the HIV reservoir in the Philippines is largely limited to prostitutes working in areas around U.S. military bases. Methodologic errors in HIV surveillance were identified and solutions recommended. Inappropriate use of highly focused sentinel surveillance data to estimate HIV prevalence in the country were the source of the misimpression. Epidemiologically based surveillance and data analysis methods were developed and proposed for use by the Philippine National AIDS Program. This review and development of improved surveillance methods was performed while the author was serving as a World Health Organization (WHO) Consultant on AIDS to the Philippine Department of Health. The findings illustrate need for careful design of surveillance systems, particularly in settings characterized by low HIV seroprevalence and limited public health resources for HIV programs.

## Abstracts

NEEDS OF INFORMAL CAREGIVERS OF HEAD-INJURED ADULTS. Joan S. Grant, Dept. of Nursing, Univ. of Ala., Bham, AL 35294. Cheryl A. Bean, Indiana Univ., Dept of Nursing, Indianapolis, IN 46202.

Although survival is the main issue following a severe head injury, those individuals who subsequently return home present a multitude of deficits. The main responsibility for managing these deficits is assumed by caregivers. In fact, recovery may be contingent upon the caregiver's ability to deal with the impact of the injury on family functioning. Although caregivers assume the major responsibility for the care associated with head-injury, little published research is available on the needs of caregivers of head-injured adults. The purpose of this descriptive study was to describe the needs of informal caregivers of head-injured adults. The sample consisted of informal caregivers randomly selected from two head injury foundations in the U.S. and a population of 750. In Phase I of a Delphi survey, informal caregivers identified needs in caring for head-injured adults in the home setting. Using the Neuman Systems Model and content analysis, needs of informal caregivers were categorized as intra-, inter-, or extrapersonal stressors. Examples of intrapersonal stressors included needs related to physical and emotional rest and more personal time. Interpersonal stressors focused on support groups while extrapersonal stressors related to finances, respite care, and programs to address the special needs of the head-injured adult. Future studies should address the importance of needs, current resources used by caregivers, and additional resources that would assist in meeting the needs of caregivers of head-injured adults. (The American Association of Neuroscience Nurses and Univ. of Ala. School of Nursing provided funds to support this study.)

HEALTH BELIEFS OF OLDER ADULTS - THE EFFECTS OF DEMOGRAPHIC VARIABLES. Dr. Sandra H. Faria, DSN, RN and Rebecca Yarbrough, MSN, RN, School of Nursing, Troy State University, Troy, Alabama, 36081.

As the aging population increases, health promotion is a growing concern for health care professionals. An individual's previous health history and cognitive attitudes play a vital role in health teaching and health behaviors. Cox's Interaction Model of Client Health Behavior was used as a framework to examine the effects of select demographic characteristics upon perceived health control among older adults. The research explored the following question: Do select demographic characteristics make a difference in perceived health control in older adults? The Health Locus of Control (HLC) Scale and a demographic questionnaire were completed by a convenience sample of 436 older adults from various community resources. Descriptive statistics were utilized to assess the demographic characteristics and analysis of variance and the Tukey Post Hoc Test were conducted to identify groups with significantly different HLC scores. The analysis revealed significantly higher HLC scores (indicating an externally controlled belief about health) for adults whose marital status was widow/widower, whose socioeconomic level was below \$6000 annually, and whose educational level was below grade 12. These findings indicate this group is "at risk" and may benefit from nursing intervention.

## Abstracts

PATIENT DISSATISFACTION AND NURSING COST: A QUALITY CONTROL ISSUE.  
Mary C. Henderson, Dept. of Nursing, Troy State Univ., Troy, AL 36082.  
Jean B. Mann, AL Board of Nursing, Montgomery, AL 36117.

The purpose of the study was to address issues of quality and cost in nursing. Specifically, a descriptive study was designed to analyze patient dissatisfiers and to identify nursing cost involved in retrospective management responsive to patient dissatisfaction. Conceptual support was derived from the quality assurance model of the American Nurses' Association. The study was conducted in one moderate sized acute care hospital in the southern region. The sample consisted of inpatients and outpatients who responded to standardized patient-satisfaction questionnaires and expressed willingness to clarify their concerns through interview with a designated nurse manager. The study was limited to patients whose questionnaires contained statements of dissatisfaction and were received during a two-month period in 1990. Previously developed institutional procedures were followed in exploring and responding to problems identified in the patient satisfaction surveys. A flow sheet was used to record the personnel category and time required for each step in the retrospective management. Nursing cost was calculated from the time required and salary bases of personnel involved in the survey follow-up. Cost data were analyzed with descriptive statistics. Content analysis was used to identify and categorize themes in statements reflecting patient dissatisfaction. Three major themes were communication, competence, and caring. Findings emphasize nursing's key role in patient satisfaction and cost containment. Implications for practice, education, and research are discussed. Particular attention is given to the application of findings to quality improvement efforts.

PARENTING AND CHILD REARING ATTITUDES AMONG HIGH SCHOOL STUDENTS.  
Elaine Marshall, Janet Alexander, Vera Cull, Ellen Buckner, Kate Jackson and Kathy Powell, University of Alabama School of Nursing, University of Alabama at Birmingham, B'ham, AL 35294-1210.

A descriptive study to determine parenting and childbearing attitudes was conducted among high school students in a greater metropolitan area. The Adult-Adolescent Parenting Inventory (AAPI) developed by Bavolek was administered to 9-12 grade students in 3 schools. Attitudes were measured using four constructs associated with abusive parenting 1) inappropriate parental expectations of the child 2) empathy toward the child, 3) value of physical punishment and 4) parent-child role reversal. Females demonstrated greater empathy for the child and higher overall parenting attitudes than males ( $p \leq .001$ ). There were significant difference among grades on empathy, role reversal and overall scores ( $p \leq .05$ ). There were no significant differences among birth order or household groups. Scores for the sample as a whole ( $n=502$ ) evidenced a wide range of parenting attitudes with 90% indicating average to highly positive attitudes about parenting. Ten percent of students scored very low, indicating need for education and possibly other support prior to assuming parent roles.



## Abstracts

EFFICIENCY OF MATERNAL SERUM HCG, AFP AND FREE ESTRIOL IN THE IDENTIFICATION OF TRISOMY 21 AND OTHER COMPLICATIONS OF PREGNANCY. Nancy Rich, Larry Boots, Richard Davis, and Sara Finley. University of Alabama at Birmingham, UAB Station, Birmingham, AL 35294.

Several screening strategies exist for the detection of pregnancies at risk for Trisomy 21. Initially, amniocentesis was offered to all women age 35 or older, identifying about 20% of all Trisomy 21 pregnancies, but none in the younger population. It was then observed that low MSAFP levels, used in conjunction with individual age-related risk, improved the detection rate for Trisomy 21-affected pregnancies by identifying an additional group of patients under 35 years of age. Recently, other serum markers have been strongly correlated with Trisomy 21. These are HCG and free estriol (FE). Using HCG and FE in combination with MSAFP and age (Profile screening) reportedly detects 60% of all Trisomy 21-affected pregnancies. Using age and MSAFP alone, 4 of 11 known cases of Trisomy 21 in our population under 35 years of age were detected (36.4%). A retrospective analysis of the same data, combining age, AFP, FE, and HCG, identified four additional cases (72.7%). These results agree with others that AFP Profile testing improves the detection of Trisomy 21-affected pregnancies. In addition to the Trisomy 21 group, other fetal complications were detected by the AFP Profile as follows: 2/4 (50%) of other aneuploidies, 5/53 (9.4%) of pregnancy losses, and 2/119 (1.7%) of premature fetuses. None of the pregnancies complicated by NTD's (8), twins (39), or other miscellaneous problems (16), were identified by the screen. This preliminary study suggests that AFP Profile testing will greatly improve detection of Trisomy 21 cases and possibly other forms of aneuploidy, but will not be useful in detecting pregnancies with problems not related to aneuploidy.

PARENTING AND CHILD REARING ATTITUDES AMONG HIGH SCHOOL STUDENTS. Elaine Marshall, Janet Alexander, Vera Cull, Ellen Buckner, Kate Jackson and Kathy Powell, University of Alabama School of Nursing, University of Ala at B'ham, B'ham, AL 35294-1210.

A descriptive study to determine parenting and childrearing attitudes was conducted among high school students in a greater metropolitan area. The Adult-Adolescent Parenting Inventory (AAPI) developed by Bavolek was administered to 9-12 grade students in 3 schools. Attitudes were measured using four constructs associated with abusive parenting 1) inappropriate parental expectations of the child 2) empathy toward the child, 3) value of physical punishment and 4) parent-child role reversal. Females demonstrated greater empathy for the child and higher overall parenting attitudes than males ( $p \leq .001$ ). There were significant differences among grades on empathy, role reversal and overall scores ( $p \leq .05$ ). There were no significant differences among birth order or household groups. Scores for the sample as a whole ( $n=502$ ) evidenced a wide range of parenting attitudes with 90% indicating average to highly positive attitudes about parenting. Ten percent of students scored very low, indicating need for education and possible other support prior to assuming parent roles.

## Abstracts

SUPPORT NETWORK UTILIZATION BY BREASTFEEDING MOTHERS. Manami Hasegawa, College of Medical Care Technology, Tottori University, Yonago, Japan, 683 and Ellen Buckner, School of Nursing, Univ. Ala. at B'ham, University Station, B'ham, AL, 35294-1210.

Many studies have suggested that multiple sources of support are necessary for breastfeeding success. The purpose of this study was to determine how the breastfeeding mother utilizes her supportive network for successful breastfeeding. The Utilization of Support Network Questionnaire (USNQ) was developed to describe breastfeeding support in ten areas. Sixty breastfeeding mothers completed the questionnaire at two weeks postpartum. Mothers rated support persons on a 5 point scale from not helpful (1) to very helpful (5). Reliability of the tool was calculated using Cronbach's  $\alpha$  as 0.93. Lactation consultants were most utilized resource for prenatal information ( $\bar{x}$  = 4.1), answering questions ( $\bar{x}$  = 3.7), and explaining principles of supply and demand ( $\bar{x}$  = 3.3). Staff nurses provided most assistance at infant's first feeding ( $\bar{x}$  = 2.5). Husbands, friends and physicians provided most assistance with decision making ( $\bar{x}$  = 3.0). Husbands offered most encouragement during difficulties ( $\bar{x}$  = 3.3) and supported mothers confidence and self-esteem ( $\bar{x}$  = 3.5). Mothers still breastfeeding at 2 weeks postpartum reported larger total support scores than non-breastfeeding mothers ( $p < .05$ ). This questionnaire reliably discriminated among professional and personal support in the various areas of breastfeeding support. This study was conducted with the support of the Kay Dahle Lactation Center, AMI Brookwood Medical Center Bham, AL.

RELATIONSHIP BETWEEN BASIC MATH KNOWLEDGE AND APPLICATION TO DRUG DOSE CALCULATION SKILLS IN FIRST YEAR BACCALAUREATE NURSING STUDENTS. Anthony W. Yother and Ellen Buckner, University of Alabama School of Nursing, UAB, Bham, AL 35294-1210.

The purpose of this study was to determine the relationship of basic math skills to drug dose calculation skills in baccalaureate nursing students. Subjects were 95 students enrolled in a nursing pharmacology course in a metropolitan university school of nursing which does not have a math pre-requisite. Subjects completed a basic math skills test and a demographic data and math background questionnaire at the beginning of the course. Scores on calculation of dosage exam were then correlated with basic math scores and subscales of fractional errors, decimal errors and proportional errors computed. Correlation between basic math test and calculation of dosage exam was significant ( $r=.41$ ,  $p < .001$ ). No significant correlations were found between subscales. Students who reported difficulty with math scored significantly lower on the basic math test ( $p < .01$ ). Students reporting high nervousness with math scored lower on both basic math and calculation tests ( $p < .01$ , both). Thus students reporting problems or nervousness with math early in the course could benefit from remedial work on other educational intervention. Also students performance on basic math test can be a useful predictor for math skills which have significance for subsequent calculation competence.



## Abstracts

Socioeconomic influence on cancer health promotion behaviors in African Americans. Linda Wilson-Thomas, Dept. of Nursing, Univ. of Ala at Birmingham, Birmingham, AL 35294-1210.

Because African Americans have higher prevalence, mortality and lower survival rates for most types of cancer, it has been suggested the differences in rates are strictly genetically preimposed. Further insight into the situation suggests the differences may be more related to a lower socioeconomic status than race. The study attempted to identify if there was a difference in high risk behaviors, attitudes about health care, knowledge about cancer and health promotion practices among African Americans of different socioeconomic levels. The study was based on the health belief model. A convenience sample of 123 participants was included in the study. The participants received their primary preventive care from either health fairs and clinics or private physicians. Results revealed there was no difference in the cancer knowledge scores based on income level, with  $p=.9441 > .05$  or the type of health group from which individual received preventive care ( $t=.25$  and  $p > .05$ ). Income levels did however make a difference in health behavior practices  $p=.0112 < .05$  with the higher on health promotion behaviors than middle and lower income groups. Education was a significant factor influencing the attitude about cancer. As the educational level increase, the more positive the individuals were regarding their attitudes about cancer ( $p=.009 < .05$ ). The lower the income the more fearful and hopeless individuals were of cancer. The gender of the individual had no significant influence on attitude about cancer ( $p=.09 > .05$ ). There also was a positive association between the type of health care received and income ( $p=.001 < .05$ ). Surprisingly the study found no correlation between attitudes about cancer and preventive behavior that was practiced ( $p=.275 > .05$ ).

INTEGRATIVE REVIEW OF TUBE FEEDING RESEARCH. Wilma Geels, RN, MSN, Univ. Hosp., Bham, AL 35294. Jane Martin, RN, MSN, and Mary Collette Smith, RN, PhD, School of Nur. UAB, Univ. Station, Bham, AL 35294.

An application of integrative review and meta-analytic strategies was made to a collection of 53 tube feeding studies from 1980 through 1988. Methodological and substantive study characteristics were examined for all studies. Effect size measures were calculated from the 10 experimentally designed studies containing sufficient data for computation. Results revealed that the 53 studies were derived primarily from the personal library of the investigators with virtually no new entries from computer or index searches. The studies were published by more than one author, with nursing and medicine equally represented. Descriptive and experimental designs were reported, with predominantly convenience samples with a mean of 50 subjects. Quality of the studies was judged to be about moderate. Topics addressed were on patients, tubes, and formulas. No theory base from nursing or any other discipline served as the basis for the studies. The mean chi-square value ( $n=10$ ) was 8.34, the mean value for  $z$  was 2.07, indicating a strong to very strong relationship between treatment and outcome.



## Abstracts

### A SURVEY OF LONG TERM CARE EDUCATIONAL NEEDS IN ALABAMA

Billie R. Rozell, College of Nursing, The University of Alabama in Huntsville, Huntsville, AL 35899. Teresa Leonard, Humana Hospital - Shoals, 201 Avalon Avenue, Muscle Shoals, AL 35661

The growing population of aged persons and their accompanying high incidence of chronic illnesses has many implications for the health care delivery system in resource planning and development to meet future health care needs. The number of hospital beds in Alabama are decreasing with a concurrent increasing demand for nursing home beds.

Nursing administrators (Directors of Nursing) in nursing homes have an increasingly important role to play in developing models of care for this segment of the health care delivery system. In addition mandatory continuing education regulations for nurses mandate identification of areas of need. In order to determine educational needs of the group of health care providers, a statewide survey was implemented in the Fall of 1990. Directors of Nursing and Nursing Home Administrators were asked to respond to an investigator developed questionnaire to identify educational needs of the Director of Nursing. Over thirty percent of Administrators and Directors of Nursing in the 220 agencies surveyed responded. Identified needs (ranked) were slightly different as perceived by Directors of Nursing and Administrators with staff motivation, staff evaluation and staff management being identified most frequently by Directors of Nursing. Administrators also noted the areas of staff motivation/management, but identified communication and leadership skills as educational needs. Identification of learning needs can help educators plan continuing education and staff development activities.

### WHITE NOISE, PUMP TIME, AND SLEEP AFTER OPEN HEART SURGERY.

Joan W. Williamson, UAH, Huntsville, AL 35899.

Disturbed sleep patterns after open heart surgery have been reported. The purpose of this study was to determine the effects of white noise and pump time on the night sleep pattern of post operative CABG patients. Sixty men and women, ages 29 - 69, having CABG for the first time were randomly assigned to a control and an experimental group. A pretest determining usual sleep patterns on a visual analog scale (Richards/Campbell Sleep Questionnaire) was given to all subjects. In the experimental group, sounds of the ocean were played throughout the night for three nights post transfer from the ICU. The RCSQ was administered to all subjects following the third night post transfer. Pump times were recorded on all subjects, as were pain, sleep, and nausea medication received. ANCOVA showed significant differences in the post operative sleep scores, indicating better sleep in the group receiving the white noise ( $p < .01$ ). ANOVA revealed that there were no significant differences in pump times in the two groups. It is concluded that white noise is a useful nursing intervention for the patient after coronary artery bypass surgery.

## Abstracts

CHEMISTRY PROFILE VARIATIONS IN DIABETIC, HYPERTENSIVE, AND OBESE SUBJECTS. Kamal S. Yackzan, Univ. of Ala., B'ham, AL 35294.  
Charles N. Krauth, Univ. of Ala., B'ham, AL 35294.

A comprehensive study on the chemical profiles of 231 subjects was performed to investigate the correlation between the study variables and selected disease states. Extensive statistical testing was used to analyze the data. This analysis compared the four disease states: diabetics(D1), obese diabetics(D2), hypertensive diabetics(D3), and obese, hypertensive diabetics(D4), to a group of healthy controls(CON). The following study variables were examined: phosphorus(PO), calcium(CA), uric acid(UA), chloride(CL), alkaline phosphatase(AP), carbonate(CO2), albumin(ALB), cholesterol(CHOL), sodium(NA), total bilirubin(TBILI), triglycerides(TRIG), potassium(K), blood urea nitrogen(BUN), total protein(TP), glucose(GLUC), and creatinine(CREAT). The first series of tests was a multi-variate and uni-variate analysis of the distribution of normal values for each variable. These tests showed GLUC to be indicative of disease in all groups. This result would only be startling if it were not found. The hypertensive groups, D3 and D4, displayed significantly abnormal values for both BUN and CREAT. Three other variables, TRIG, UA, and AP also displayed erratic results. The second series of tests began with an analysis of variance. For significant results, a follow up analysis using Student-Newman-Keuls and least significant difference was performed. The results of this testing indicated that serum levels of PO, CL, ALB, BUN, K, GLUC, and CREAT were affected by the diseases in question. Additional testing taking race and sex into account, showed PO, CL, UA, AP, NA, BUN, GLUC, and CREAT to vary among the disease groups.

HEAD INJURY: IMPACT ON THE FAMILY. Doris C. Ford, RN, DSN, Dept. of Nursing, Jacksonville State Univ., Jacksonville, AL 36265.

Each year in the United States there are more than 800,000 serious head injuries which result in traumatic brain injury; 50,000 to 90,000 individuals suffer injuries which leave life-long residual deficits. Scant research has been reported regarding the effect these injuries have on family members. The purpose of this study was to describe the impact that head injury has on the family.

A preliminary study was conducted using a sample of 13 drawn from families of survivors who had returned to their home community after treatment for traumatic brain injury. A questionnaire (McMordie, 1987) was mailed with a cover letter explaining the study. Responses were analyzed using descriptive statistics.

Findings revealed that males outnumber female survivors more than two to one. The mean age was 24 years. More than three-fourths of the injuries resulted from automobile accidents. Difficulties experienced by families and ranked according to severity were lack of information, financial expenditures, health problems and social isolation.

(Study funded by Faculty Research Grant, Jacksonville State University, Jacksonville, AL 36265)

## Abstracts

DIETARY HABITS, BLOOD GLUCOSE, AND BLOOD PRESSURE IN THE ELDERLY.  
Portia Foster, College of Nursing, Jacksonville State University,  
Jacksonville, AL 36265

Health care professionals need to assess the dietary habits of the elderly to identify factors that effect body functioning. A descriptive design was utilized to assess a segment of the elderly population. The conceptual framework was derived from Orem's Self Care Theory. The purpose of the study was to describe the dietary habits, glucose and blood pressure levels of the elderly. A convenience sample of thirty seven elderly persons, aged 66 to 93 years, were drawn from a senior citizen center in a southeastern state. Twenty seven females and ten males participated in the study by allowing their blood pressure to be taken, permitting one fingerstick for glucose testing, and answering questions concerning their dietary habits. The hypotheses were tested using descriptive statistics. From the findings, it was concluded that men in the sample ate more meals alone than the females. The elderly were found to eat an average of 2 - 3 meals a day. Glucose levels were found not to be within the normal range. It was concluded that the blood pressure levels of the elderly in this sample were generally not within the normal range. Implications from this study involve intervention planning and counseling needs. With the identification of present body functioning, appropriate interventions can be planned to improve or maintain the elderly person's dietary patterns. It is recommended that this study be replicated in different settings and in several geographical locations. It is further recommended that studies be conducted using other measures of body functioning.

NURSE-MIDWIFERY EDUCATION IN ALABAMA. Judith S. Melson-Mercer, Univ. of Ala. School of Nursing, Birmingham, AL 35294.

The University of Alabama School of Nursing, University of Alabama at Birmingham, is offering the first nationally accredited program to educate nurse-midwives in Alabama. The new Nurse-Midwifery Option is housed within the existing Maternal-Infant Nursing Major in the master's degree program. In a five quarter, 57 semester hour option, the School will prepare nurses at the graduate level to perform in the expanded role of the nurse-midwife in the delivery of primary health care to women and babies including the management of normal antepartum, intrapartum, and postpartum care as well as family planning and gynecology. Accredited by the American College of Nurse-Midwives, the program is offered with the support of the Division of Maternal-Fetal Medicine, Department of Obstetrics and Gynecology at UAB. Classes will be admitted annually in September of each year. The outcome of the option will be a master's prepared nurse-midwife who will be eligible to sit for the certification examination offered by the American College of Nurse-Midwives. The program addresses two critical and interrelated needs: increase access of qualified nurses to graduate nurse-midwifery education and increase in the number of CNMs who are prepared to provide primary health care to childbearing women and their infants of Alabama and the South. An overview of the program will be presented.



## Abstracts

BLACK AMERICANS' KNOWLEDGE LEVEL OF FOODS HIGH AND LOW IN SALT. LaGloree Dawn Hill, University of Alabama at Birmingham School of Nursing, University Station, Birmingham, AL 35294.

Salt is a hidden ingredient in many of the foods eaten daily by members of the black community. Salt sensitivity is one theory presented as the reason for the high incidence of hypertension in the black community. The purpose of this study was to assess black Americans' knowledge regarding the salt content in foods. Sixty-seven volunteers completed a questionnaire. Subjects were asked to choose foods high and low in salt content. Subjects' scores ranged from -2 to 10 (out of a possible 11) with a mode of 7 when choosing foods low in salt, and scores ranged from -1 to 12 (out of a possible 14) with a mode of 5 when choosing foods high in salt. Using t-test a difference was observed between well informed and not well informed subjects in choosing low salt foods ( $p=0.047$ ) but not in choosing high salt foods ( $p=0.731$ ). When hypertensive subjects were compared to normotensive subjects there was no significant difference in the selection foods low in salt ( $p=0.814$ ) or foods high in salt ( $p=0.147$ ). No significant difference was found between the sexes in choices of foods low in salt ( $p=0.39$ ) but there was a difference in choices of foods high in salt ( $p=0.006$ ). The results of this study concluded that for this sample there is insufficient knowledge regarding the salt content in foods.

A DESCRIPTION OF THE MATERNAL DECISION-MAKING PROCESS REGARDING CIRCUMCISION. Cathy L. Rozmus, School of Nursing, Belmont College, Nashville, TN 37212-3757.

At the birth of an infant, a mother as a dependent-care agent for her infant, begins a series of decisions about her infant's health care. A conceptual framework consisting of Orem's (1988) model of deliberate action during dependent-care and Fishbein and Ajzen's (1975) theory of reasoned action was proposed as an explanation of the maternal decision-making process. A qualitative descriptive study was conducted to determine if the proposed conceptual framework could provide an accurate description of the maternal decision-making process regarding circumcision. Semi-structured interviews were conducted with 20 mothers of male infants less than 72 hours of age in a regional hospital in the Southeastern United States. Content analysis was performed on the transcripts of the interviews with the concepts from the model of deliberate action during dependent-care and the theory of reasoned action as the categories utilized during classification of themes. The phase of decision-making in the model of deliberate action during dependent-care and the components of the theory of reasoned action were identified from the transcripts. Therefore, the conceptual framework was supported by the findings. Recommendations for future research include further development of the conceptual framework.

## Abstracts

### CORRELATES OF SUICIDE AND HOMICIDE RATES IN ALABAMA COUNTIES.

Charles E. Joubert, Department of Psychology, University of North Alabama, Florence, AL 35632.

The purpose of this study was to observe the relationships of specific demographic and social stress or disorganization indices to the suicide and homicide rates in the 67 Alabama counties for the period 1978-1988. Data regarding these indices came from various official state and federal reports. The results indicate that the average suicide and homicide rates per year varied considerably among the counties, posing some difficulties for hypotheses of instinct-based aggression or a "culture of violence." Counties with higher suicide rates tended to have lower birth rates, lower illegitimacy rates, older median population ages, smaller percentages of residents below the poverty level, smaller percentages of nonwhite residents, higher per capita incomes, smaller percentages of college graduates, more migration, and higher divorce rates. Counties with higher homicide rates tended to have larger percentages of nonwhites, higher birth rates, higher illegitimacy rates, larger percentages of residents below the poverty level, younger median population ages, lower divorce rates, and less migration. Suicide rates correlated negatively with homicide rates. While the homicide rates for the counties generally correlated positively with indices of social stress, the relationship between the suicide rates and social stress was less clear. Additional analyses indicated that homicide rates were higher in the four major cities' counties while the other metropolitan counties had lower rates than even the rural counties. Finally, the "dry" counties had lower homicide rates than did the "wet" counties.

### RELATIONSHIP BETWEEN BASIC MATH KNOWLEDGE AND APPLICATION TO DRUG DOSE CALCULATION SKILLS IN FIRST YEAR BACCALAUREATE NURSING STUDENTS.

Anthony W. Yother and Ellen B. Buckner, University of Alabama School of Nursing, UAB, B'ham, AL 35294-1210.

The purpose of this study was to determine the relationship of basic math skills to drug dose calculation skills in baccalaureate nursing students. Subjects were 95 students enrolled in a nursing pharmacology course in a metropolitan university school of nursing which does not have a math pre-requisite. Subjects completed a basic math skills test and a demographic data and math background questionnaire at the beginning of the course. Scores on calculation of dosage exam were then correlated with basic math scores and subscales of fractional errors, decimal errors and proportional errors computed. Correlation between basic math test and calculation of dosage exam was significant ( $r = .41, p < .001$ ). No significant correlations were found between subscales. Students who reported difficulty with math scored significantly lower on the basic math test ( $p < .01$ ). Students reporting high nervousness with math scored lower on both basic math and calculation tests ( $p < .01$ , both). Thus students reporting problems or nervousness with math early in the course could benefit from remedial work on other educational intervention. Also students performance on basic math test can be a useful predictor for math skills which have significance for subsequent calculation competence.



## Abstracts

THE RELATIONSHIP OF PERCEIVED SOCIAL SUPPORT AND HEALTH BEHAVIORS IN PREGNANT WOMEN RECEIVING PRE-PAID CARE. Judith S. Melson-Mercer, Univ. of Ala. School of Nursing, Birmingham, AL 35294.

This study examined the relationships between client characteristics including perceived social support, health behaviors, and weeks gestation at the first prenatal visit in black and white women receiving pre-paid, uniform health care. The Interaction Model of Client Health Behavior (Cox, 1982) provided the theoretical framework. This descriptive comparative ex post facto study was conducted in a large health maintenance organization. Eighty black women and 82 white women were purposively selected and completed a questionnaire which included the Personal Resources Questionnaire Part II (Brandt, 1985) to measure social support and the Personal Lifestyle Questionnaire (Brown & Muhlenkamp, 1983) to measure health behaviors. Multiple regression analyses demonstrated the ability of the independent variables to explain 45% of the variance in health behaviors. The variables best predicting health behaviors were: socioeconomic status of the father, social support, general well-being, and intrinsic motivation. Canonical correlations of the variable sets were significant with the coefficients weighted on socioeconomic status of the father and social support for health behaviors. One implication of this study is the need for more health behavior education earlier and more frequently in the pregnancy for women and their husbands/partners of lower socioeconomic status. Strategies to include men in early pregnancy education need to be explored. Literature developed especially for men, including those with low literacy levels, for early pregnancy teaching may be helpful.

NURSE'S ATTITUDES AND PRACTICES RELATED TO EXERCISE PROMOTION AND PRESCRIPTION. Ramona B. Lazenby, Betty R. Barfield, H. N. Williford, and M. S. Olson, Auburn University at Montgomery, Montgomery AL 36117.

One hundred thirty seven (137) nurses responded to a survey to determine their attitudes and practices related to exercise and the development of exercise prescriptions. The mean age of the respondents was  $41.6 \pm 9.7$  years with the majority being females (91%). Results of the survey found that 37% queried their patients about exercise and 69% encouraged their patients to exercise; however only 14% developed exercise prescriptions for their patients. Five percent of these nurses said patients were referred to them from other health care professionals for the development of exercise prescriptions. Only twenty percent of the nurses surveyed were familiar with the American College of Sports Medicine guidelines on the development of exercise prescriptions, and only eight percent had ever taken a course related to exercise physiology and the development of exercise prescriptions. The majority (89%) felt there was a definite need in nursing school for coursework related to the physiological aspects of exercise and the development of exercise prescriptions. Results of this investigation indicate that while many nurses support exercise for the health of their patients, greater emphasis should be placed on teaching nurses the physiology of exercise as well as how and when to write exercise prescriptions.



## Abstracts

COMPARISON OF DOCTORAL DEGREES IN NURSING: ACADEMIC VS PROFESSIONAL. Linda Reed and Myra A. Smith, School of Nursing, Univ. of Ala. at Birmingham, UAB Station, B'ham, AL 35294.

Historically two distinct types of doctoral degrees have been developed, the professional and the academic degrees. These two degrees were conceived as fundamentally and philosophically different. The professional degree was defined as an applied degree, and practice oriented. The focus was on integrating advanced clinical practice and research. The academic degree emphasized statistics, research, and theory development with the generation of new and fundamental knowledge through basic research. However, in reality no significant differences have been found between these two degrees. The curriculum designs in regard to clinical hours and theory content are not dramatically different. Dissertation topics cannot be differentiated according to the definition of the professional and academic degrees. Following completion of either degree, career paths are not significantly different. Even though no significant differences can be identified, there continues to be a definite trend toward the academic or PhD degree. Currently, there are 53 doctoral programs. Of this number, 74% are PhD programs. During the last 5 years, 14 new doctoral programs in nursing have been established, with 79% of these being PhD programs. Reasons for this trend may be that the PhD is a more widely recognized degree, with more prestige, and possibly more marketability than professional degrees.

PRERETIREMENT PLANNING IN FEMALE REGISTERED NURSES. Stephanie D. Gullotte, College of Nursing, University of South Alabama, Mobile, AL 36688.

The purpose of this research was to test a model for understanding preretirement planning among working women, and to describe and explain the preretirement health and financial plans of a select group of working women. The sample consisted of 145 working female registered nurses, 40 years of age and older. Roy's (1984) role function model was the theoretical framework used to guide this research. A multivariate method of analysis was used with a criterion of .05 level of statistical significance. Data were obtained through the use of a questionnaire formulated from three different instruments: Attitudes Toward Retirement, developed by Glamser (1976); the Retirement Success Profile, developed by Johnson (1979); and the Preretirement Scale, developed by Boyack and Tiberi (1975). Together, these instruments measured knowledge, beliefs, and attitudes of women regarding health and financial preretirement planning. The results of this study indicated that formal and informal methods of planning for retirement were limited. Knowledge of health maintenance issues were found to contribute to variance on preretirement health planning, and knowledge of economic issues were found to contribute to variance on preretirement financial planning. Implications for practice, education, and research were derived.

ENGINEERING AND COMPUTER SCIENCE

**PARALLEL C PREPROCESSOR.** Gopalakrishnan R. Keertinagar, Dr. Robert M. Hyatt, Dr. Warren T. Jones, Dept. of Computer and Info. Sciences, Univ. of Ala., at Birmingham, Birmingham, AL 35294.

A preprocessor performs macro substitution on program text, includes other source files and conditional compilation. It is a UNIX filter that supplies input to the standard C compiler on the target machines. Current parallel implementations in the C rely heavily on the standard C library macros which are neither readable nor reliable. This preprocessor addresses these issues by implementing an extension to the C. The programming directives clearly define the parallel operations and are more readily apparent to user. It thus contributes to the Software Engineering goals of a) understandability, b) modifiability, c) reusability and d) portability. The project goals were to provide 1) Parallel programming directives through an appropriate extension of the C, 2) "Correct" primitives such as barriers, locks, events, critical regions, semaphores, and others thereby providing the programmer with basic reliable operators, 3) Fullest syntax checking that ensure correct implementation of primitive operators which necessitates only algorithm debugging, 4) As much portability as possible so that the user need not worry about architectural details. It is unlikely that vendors will agree on parallel processing directives/syntax since so much time and money is invested in current compilers and other software. Therefor this preprocessor provides an alternative solution with no adverse effects on program development or maintenance, thus adhering to software engineering principles. The preprocessor does not analyze program paths exhaustively to eliminate deadlocks when using parallel primitives. While it is an excellent tool, the programmer still has to debug logic.

APPROPRIATE SURFACE COATINGS FOR WOOD PRESERVING PLANT DRIP PADS TO MEET 1991 EPA STANDARDS. John Ball and Jay K. Lindly, Dept. of Civil Eng., Univ. of Ala., Tuscaloosa, AL 35487-0205.

New US Environmental Protection Agency regulations which become effective in June, 1991 mandate the application of impermeable sealers to the surface of existing concrete drip pads at wood preserving plants. This requires the application of coatings technology to an industry that has not previously utilized these types of materials. An ideal coating material for this application must meet a number of specifications. Most importantly, the surface sealer must be impermeable, resistant to wood preservatives, adhere well to concrete and rail, flex with temperature changes in the concrete, be able to span cracks and joints in concrete, have good impact resistance and be capable of being repaired easily in the field. In addition, the coating must withstand ultraviolet attack by the sun and be relatively inexpensive. This paper lists the extent to which coatings must meet these specifications and recommends generic coating types that are commercially available and appropriate for this application.

## Abstracts

COMPUTER APPLICATIONS FOR MANAGEMENT OF PROFESSIONAL PRACTICES. Joseph E. Boyett Jr., DBA, Division of Computer & Information Science and Mathematics, Troy State University in Montgomery, Montgomery, AL.

An increasing number of professional practices operate their own computer systems. Unfortunately, owners and office managers of professional practices typically know very little about computer systems. As a result, a practice may buy a computer system which is much more expensive and much less capable than actually needed. A practice should justify its purchase of a computer system from both expected reductions in labor costs and increases in revenue. Labor savings are often the easiest factor to predict because computer systems automate many tasks which were previously performed by manual methods. This study examined over 400 professional practices in Alabama to determine the potential labor savings which might result from automation. The study identified six functions which are primary candidates for automation. Tasks within these functions, if automated, could produce over eighty percent of the potential labor savings associated with installing a computer system. The primary candidates for automation are: Accounts Receivable, primarily patient billing and third party billing; Patient Management, primarily patient recall and appointment scheduling; Management Reports; Correspondence; Accounts Payable; and Payroll. A model was constructed which predicts labor savings for the cited primary candidates based on the size of a practice. Total benefits from reductions in labor costs and increases in revenue should exceed the system's cost if a purchase is to be economically feasible. If labor savings from the cited tasks do not come close to the cost of a planned computer system, then the system is probably not feasible.

VISUAL THINKING IN ENGINEERING. Stan Vitton and Jay K. Lindly, Dept. of Civil Eng., Univ. of Ala., Tuscaloosa, AL 35487-0205.

An essential aspect of engineering is the ability to think visually; to develop mental images of the problems and solutions that we must deal with and develop. However, we generally do not fully develop our ability to think visually. According to Rudolf Arnheim, a noted art psychologist, thinking must involve both perception (visualizing) and thinking (reasoning). Unfortunately, perception, although considered indispensable in thinking, has been considered an inferior cognitive function. The business of creating concepts, accumulating knowledge, separating, and inferring was reserved for the "higher" cognitive functions of the mind. Historically and even within our current educational systems we have maintained the inferior status of perceptual thinking. This paper will attempt to address some of the aspects of visual thinking in Engineering and will cite some of the concerns that the authors have in what we perceive as the continuing decline in our ability to think visually.



## Abstracts

LOAD DISTRIBUTION IN RECTANGULAR BULK STORAGE BINS. Robert Brown and Jay K. Lindly, Dept. of Civil Eng., Univ. of Ala., Tuscaloosa, AL 35487-0205.

An industry in Alabama fabricates bulk storage bins and markets them worldwide for the typical use to store granular, cohesionless materials. The complete storage facility consists of individual modular bin units which can be constructed side by side and stacked one upon top of another to accommodate the owner's functional requirements. The bin system is elevated above the ground on a structural steel framework (the substructure) in order to allow trucks to pass below the hoppers. The company fabricates standard bin units which are intended to accommodate a wide variety of fill materials and a wide range of tier heights. On the other hand, the substructure is designed for each installation to account for the type of material to be stored, the configuration required by the owner, and other site dependent factors. The focus of this paper is the investigation of several factors pertinent to the design of the substructure. The mechanisms by which the load from the weight of the bin system and the weight of the fill material is distributed down through the bin system into the substructure is not well understood. Some portion of the total load is distributed directly to the substructure columns by the bin system as a result of friction between the bin walls and the fill material. Consequently, this part of the load is not supported by the substructure beams. However, since the load carrying mechanisms of the bin system is not well understood, the load carried directly to the substructure columns has not been quantified and is neglected in the design of the substructure beams. In this research, the load carrying mechanisms of this system is investigated and the actual loads supported by the substructure beams are quantified. The variables considered in the study are the weight density of the fill material, the coefficient of friction between the bin walls and the fill, and the tier height of the system.

THE USE OF COMPUTER SIMULATIONS IN TEACHING MARKETING COURSES. Gerald Crawford and William S. Stewart, School of Business, University of North Alabama, Florence, AL 35632-0001

Lectures and multiple choice questions have been cited as highly inefficient and ineffective in teaching marketing courses at the college level. A major study reported that these widely used teaching practices do not encourage creativity, integration, problem solving, decision making, risk taking, or interpersonal skills. Case analysis is a step in the right direction, but its major weakness is that decisions are made in a static environment. Students do not have to execute these decisions and live with the consequences. Nor are they required to respond to competitive moves and counter moves.

In a recent study the principal researchers examined the use of a computer simulation over an 11-year period. It was found that the simulation encouraged "hands-on" involvement, teamwork, and enthusiasm. Further, it dramatically demonstrated the need for a balanced marketing program and the need to cover all costs in the long-run. Participants in classes using the marketing simulation reported that it was the most relevant and memorable part of the course. There are drawbacks, however, when a simulation is used: (1) More time is required for the teacher to use it over lectures and cases, (2) students try to find "the magic formula," (3) the "grapevine effect," and (4) a simulation generally cannot be used alone.

UTILIZING INITIAL REQUIREMENTS DOCUMENTS WITHIN SYSTEM MODELING. David Cordes, Department of Computer Science, University of Alabama, Tuscaloosa, Alabama, 35487-2090.

The process of system specification is of vital importance to the overall success of a given software project. The most commonly identified point of failure in large-scale software projects is the inability of the development team to properly identify and define the initial set of domain-specific requirements demanded by the user community. These errors, due to incorrect specifications or problems in the specification, are the cheapest to fix if caught during the specification, and the most expensive to correct later in the life-cycle. Conventional development of the system model involves an examination of the initial requirements document, but relies primarily on the development team to generate the initial system model. The development team is not bound by the information within the initial requirements document. Additionally, no formal techniques exist for extracting the domain-specific information present within the initial requirements documents. This research presents a technique for the initial modeling of software systems based solely on the information present within the initial requirements document. This model directly reflects the views of the document's author, a member of the user community for the proposed software. Thus, the user's input into the modeling process is strengthened. While the development team must still refine and complete the prototype model, it forms a solid, user-oriented foundation for software development. The methodology identifies a three-step procedure for system modeling. The first phase involves a syntactic-based parse of the initial document, a natural language text. The second phase then translates the parsed-sentence structures into a formalized knowledge representation scheme. Finally, this set of information is utilized to generate the preliminary system model. In addition, traceability information exists within this knowledge base, thus allowing the development team to trace the origin of information present within the system model.

GRAPHICAL USER INTERFACE DESIGN BY DIRECT MANIPULATION USING THE OBJECT ORIENTED PROGRAMMING (OOP) PARADIGM. Rustom K. Vachha, Dept of Computer and Information Sciences, University of Alabama at Birmingham, Birmingham, AL 35294.

The *Object Oriented Paradigm* is gaining popularity amongst system designers due to its apparent advantages. In this paper, the feasibility of the object oriented approach for the development of a *Graphical User Interface* (GUI) is considered. User Interfaces based on windows, mice and bitmap displays are common-place today. There is a growing need to develop interfaces with scroll bars, radio buttons, pull down menus and browsers, besides a plethora of visually pleasing utilities that range from varying the size of windows to changing the text font and many others. As the interface becomes more complex, the design becomes very demanding. Object Oriented designing circumvents this problem by declaring the various building blocks of the GUI as *objects* and creating general-purpose functions which are passed as *messages* for manipulating these objects of the GUI. This paper illustrates how application specific GUIs could be *designed* by *direct manipulation* of these objects. A tool-kit that contains these building blocks as well as the general-purpose functions can be provided to the application designer. Due to its simplicity and high level nature, application specific GUIs can be designed without the need for the application designer to understand the intricacies involved in the low-level implementation of the GUI. The properties of data encapsulation and inheritance, which are features of object oriented programming are implemented.



**SCIENTIFIC VISUALIZATION AUGMENTED WITH A HAPTIC INTERFACE MAY HELP UNDERSTAND ARTIFICIAL NEURAL NETWORKS BETTER.** Rustom Kersasp Vachha, Dept of Computer and Information Sciences, Univ of Alabama at Birmingham, Birmingham, AL 35294.

This paper outlines a new concept in exploring and training artificial neural networks with the aid of our visual and haptic senses. With the high quality of hardware support available in graphics workstations, it is now possible to scientifically visualize statistical information (data) contained in the network, and graphically display it. Our haptic senses could prove to be an effective tool to help *feel* the present *state* of the neural network system. The transducer for the haptic senses could be a type of "glove" that helps transform the network's state into a sensory stimulus that can be interpreted by the observer to represent the present state of the network. Haptic displays have been used for Scientific Visualization by chemists to solve the complex molecular docking problem. This is the first instance of haptic displays being used for neural network simulations. We can configure a minimum system to serve our two fold need of a haptic interface as well as scientific visualization. The configuration includes a graphics workstation, a haptic interface to communicate with the workstation, and one virtual screen each to output the visualized scientific data and the frame of reference for the network under consideration. Our aim is three-fold:- \*to *explore* the synapses of the network during training by seeing how the energy level of the system changes according to the change in weight of the synapse; \*to visually interpret the state of the system using scientific visualization techniques like contouring, rendering and other effects; and \*to manipulate the connection strength at the synapse in order to stabilize the system (during the training phase). These goals will certainly prove beneficial in understanding neural networks better. Stress is also paid on developing a good graphical interface that depicts the state of the network dynamically at all times. Options are also provided to draw contours to show regions of similar energy levels connected together in the network. Different color schemes with rendering can be provided to explicitly contrast the energy state of the node at any given time. This project is now in its design phase.

**DESIGN AUTOMATION OF POWER DISTRIBUTION SYSTEM USING CAD.** Faizal Eledath, Dept. of Computer and Information Science, University of Alabama at Birmingham, Al-35294.

Due to the increasing competition, cost and time constraint, the Power Distribution Panel manufacturers are looking for an alternate to the conventional method of manual designing. A CAD package, **CADPanel**, is developed which automates the major power distribution panels namely the Medium Voltage (MV) Panel, Sub-switch Board (SSB) and Distribution Board (DB). CADPanel has the following features :- (1) It gives an optimal layout of the required Panel. (2) It gives details of the manufacturing cost incurred. (3) It gives the bill of materials. The package has an added advantage in terms of speed, accuracy, 3-D viewing and easy correction facility. The package is also used as a tool in developing the schematic for the entire power distribution layout in any industry. The package has been implemented using AutoCAD (release 10) and the programming language used is AutoLISP. This package was developed as part of a project for Industrial Engineering Services, Coimbatore, India.



**SIMULATED OPERATING SYSTEMS.** Robert A. Allen, Department of Computer Science, The University of Alabama, Tuscaloosa, AL, 35487-0290.

The Computer Science Department at The University of Alabama has adopted a rather unique approach to teaching its graduate level Operating Systems (OS) course. For the past two years this course has been devoted to the development of an OS simulation package which visually illustrates various computer system performance issues. This approach yields two direct educational benefits. First, since our students are actually coding this package, they are exposed to a large scale synchronization problem which, in effect, simulates the internal decisions of an OS. This package provides routines which independently simulate various components of a computer system and its users. Each instantiation of these routines signifies a separate component which is active in the simulated system. These independent processes must communicate with a Supervisor in order to be synchronized in the simulation. The coding of this project illustrates to our students many of the classical synchronization problems. The second direct educational benefit that our students receive from this course is the knowledge they gain from using their simulation packages. Their simulation packages allow them to play system designer and to tune the system to "optimal" performance. They are also confronted with the serious issues involved with defining the term "optimal." They are no longer allowed to merely *believe* the textbooks, but can explore their own systems and discover (or shall we say, rediscover) the effects that system tuning has on both hardware component's performance and on the users of the system. Since each student's package includes simulated users, they are also capable of seeing the effects that different user populations have on system performance.

**DEVELOPMENT OF A CONCURRENT PROGRAMMING MODEL IN C++.** Viswanathan Vaidyanathan, Dept. of Computer and Information Sciences, University of Alabama at Birmingham, Birmingham, AL 35294.

A concurrent programming model, similar to Actors, is developed in C++. The actor model is based on the message passing mechanism. Concurrent programming concepts are included in the object oriented metaphor with the aim of allowing multiple, independent and interacting objects. An inheritance based language like C++ aids in the development of an actor-like model. The class structure of C++ is utilized in developing the different components of the actor, the instances of classes being the active objects. There was a wide range of challenges such as mapping the objects in C++ to the processes in Unix, implementation of the model in traditional architectures like the shared memory architecture, etc., during the course of the project. The member functions of the different actors, which are active objects, are implemented using Unix processes and the message passing between the actors is done using various Unix interprocess communication facilities. A concurrent execution of the prototype model is being done in a shared memory environment on the Sequent Balance 21000 with 30 processors.

ESTIMATION OF BACTERIAL DENSITY UTILIZING THE SCANNING ELECTRON MICROSCOPE. Peggy S. Reese and James V. Walters, Dept. of Civil Eng., Univ. of Ala., Tuscaloosa, AL 35487-0205.

Traditional microbiological methods have been the foundation of any study involving microorganisms. Cultural methods such as enrichment cultures, most-probable-number counts, standard-viable-plate counts, and direct-light-microscopy counts are the usual means of enumeration of microorganisms in samples taken from the environment. Limitations of these traditional methods have been reviewed. Viable-counting procedures do not provide representative sampling of natural populations and are selective preferentially for single-celled organisms even though filamentous organisms commonly are observed in natural environments. Another disadvantage is the low efficiencies of plating media in producing colonies. The objective of this study is to determine a counting procedure for the scanning electron microscope (SEM) that is statistically significant. A pure culture of bacteria was diluted serially and enumerated by the standard-viable-plate-count method. Each dilution was plated in triplicate and counted at 24 hours and 48 hours. Each dilution also was filtered onto 25-mm Nuclepore filters in triplicate. Each filter was prepared for viewing in the SEM. Random fields of each dilution were photographed in the SEM and the bacteria were enumerated. Three landfill leachates were evaluated for indigenous microorganisms. Enumeration was conducted by standard-viable-plate counts and the SEM direct-count method developed.

TUPLE-SPACE WITHOUT LINDA. Lewis Patterson and Robert Hyatt, University of Alabama at Birmingham, Birmingham, Al. 35294.

Tuple-space is the underlying model for Linda, which is normally implemented by compiler modifications to provide a set of syntactic/semantic language extensions. Linda was designed for the traditional MIMD environment. We have separated the tuple-space concept from the complexity of compiler modification and focused its simple elegance on the distributed environment.

Tuple-space is a network-global storage space in which the unit of storage is a tuple consisting of key and content. These persistent storage objects are addressed associatively via their key. The tuples along with a small set of primitives provide for interprocess communication, synchronization, and creation. A network of Unix systems may be linked using tuple-space to form a powerful multiprocessor suitable for use with medium to large grain parallel algorithms.

## Abstracts

### THE SELECTION AND USE OF COMPUTER SOFTWARE BY SMALL BUSINESSES.

T. Morris Jones and Gerald Crawford, School of Business, University of North Alabama, Florence, AL 35632-0001

The computer software industry has undergone dramatic changes in recent years. This is especially true in the development and marketing of word processing, spreadsheet, and database packages offered for sale by various software firms. Micropro International developed Wordstar in 1979 and quickly became the industry leader. Ten years later, however, the firm had dropped to 49th place. It is felt that the decline came about because it lagged behind in providing upgraded programs and failed to supply toll-free customer support for its products and services.

One-hundred small public and private organizations were contacted to learn what computer software "packages" were used and to determine how they came to select one over another. Ninety percent of all respondents used a word processing program. Various organizations used these programs primarily for text handling. WordPerfect and Wordstar were widely used along with a variety of others. They were selected mainly because they were "easy-to-use." Forty-five percent of all respondents used spreadsheet programs, and they used them primarily for accounting purposes. Lotus 1-2-3 was the favorite by far. Most software packages were generally selected on the basis of: (1) advice from an associate, (2) advice from someone in their office, or (3) advice from someone in another office.

LOGICAL VIEWS FOR OBJECT-ORIENTED DATABASES. T. Dean Hendrix, Dept. of Mathematical, Computing and Information Science, Jacksonville State University, Jacksonville, AL 36265.

Object-oriented database systems trace their origins to the object-oriented programming model. The basic idea in each case is to raise the user's level of abstraction. Instead of thinking in terms of computer-oriented constructs such as files, records, and fields, the user is encouraged to think in terms of objects, which more closely parallel the entities in the real-world problem space.

Although it represents a major achievement in the database field, the object-oriented database model is not a panacea. While providing excellent solutions in some application areas (CAD/CAM, CASE), this model still falls prey to fundamental limitations such as multiple inheritance issues and inefficient queries on the hierarchy.

This paper presents ideas that seek to add John Shilling's logical views to the object-oriented database model to alleviate some of the problems and enhance its power.



## Abstracts

AN AXIOMATIC THEORY OF SOFTWARE TEST DATA ADEQUACY CRITERIA. Allen S. Parrish, Dept. of Computer Science, Univ. of Ala., Tuscaloosa, AL 35487-0290.

Software testing, like many technological disciplines, is motivated entirely by practical concerns. Most theoretical work is therefore driven by a desire to find the best ways of performing testing by the practitioner. However, little work has been done to develop a foundational theory to address the fundamental issues that support the discipline. Such a foundational theory should provide definitions of the basic concepts of the discipline, as well as a model of how these concepts are interrelated. An example of such a concept is an "adequacy criterion." In this paper, I show how a foundational axiomatic theory can be developed for adequacy criteria, that is modeled after theories from more traditional mathematical and scientific disciplines.

A PARTICIPANT'S EVALUATION OF THE FIRST USES AND ASCE BILATERAL WATER RESOURCES CONFERENCE IN MOSCOW IN JUNE, 1989. James V. Walters, Dept. of Civil Eng., Univ. of Ala., Tuscaloosa, AL 35487-0205.

The author attended the first bilateral USES/ASCE Water Resources Conference that was held in Moscow, U.S.S.R. 8-10 June 1989. The hosts, the Union of Scientific and Engineering Societies, selected Soviet authors for two dozen papers, and the American Society of Civil Engineers selected excellent American authors to present our perspectives upon the same subjects addressed by the Soviets for the conditions in the U.S.S.R. The conference was followed by a two-week technical tour of the U.S.S.R. The author presents his impressions from his experiences from the conference and tour in a nation that now is being subjected to extremes of cultural and political change.

BIOMONITORING TO IMPLEMENT WATER-QUALITY-BASED TOXICS CONTROL. L. Faye Jones and James V. Walters, Dept. of Civil Eng., Univ. of Ala., Tuscaloosa, AL 35487-0205.

During the last decade the biomonitoring of treated municipal and industrial wastewater effluents has been proposed and initiated. It appears that the proposed implementation will be more problematic and devastatingly expensive than the public has even begun to perceive. In this paper the authors review the statutory and regulatory authority for biomonitoring. The federal and state regulatory perspectives are reviewed. The scientific perspectives of the testing methods are examined, and the perspectives of municipal and industrial dischargers precede the presentation of case studies that will allow appreciation of the extreme costs and difficulties our industries and municipalities will face.

## Abstracts

LAB EXERCISES BASED ON THE SCIENTIFIC METHOD. R. Dale Johnson, Dept. of Mathematical, Computing, and Information Sciences, Jacksonville State University, Jacksonville, AL 36265.

Lab exercises for introductory computer programming courses can make use of the scientific method to allow students to "discover," through experimentation, more about their text editors, operating systems, and the causes of common syntax and run-time errors. In most cases, the students could see a language construct in the lab before it has been discussed in class. Once they have completed the lab, the classroom discussion builds on what they discovered in their experiments. Even students who do not successfully complete the lab have a deeper understanding of course topics than they would if they had not even attempted the lab. In this way, the classroom lecture becomes less abstract.

## ANTHROPOLOGY

MEDICAL TREATMENT CHOICES IN THE NORTHERN PERUVIAN ANDES. Kathryn Oths, Dept. of Anthropology, Univ. of Ala., Tuscaloosa, AL 35487.

The accessibility of biomedical treatment has long been considered one of the primary predictive variables of people's medical treatment choices, particularly in third world contexts. Accessibility has generally been operationalized into two component parts, the transportation to and the cost of services. In my research in Chugurpampa, an Andean campesino community where people have access to both western and traditional medicines, I have encountered evidence that calls for a clarification of certain accepted notions of accessibility. Transportation in most studies has been concerned with the ability to reach biomedical practitioners as if the same set of difficulties did not apply in obtaining access to traditional healers. Furthermore, access is often erroneously equated with the nearness of services, as assumption which does not apply when dealing with particular types of practitioners, such as shamans (curanderos) and physicians. A high cost of treatment has been frequently cited as a deterrent to seeking modern medical care when an illness is critical, especially for those of the lower socioeconomic strata. On the contrary, my observations show that high treatment cost tends to inhibit use at the mild and moderate stages of illness severity for lower income families, but is not a determinant of choice when the illness is grave. This is explained in cultural terms by additional resources being available to a person in times of crisis through the socio-religious practice of compadrazgo, a type of ritual kinship prevalent in the Andes. Findings are based on data gathered during 18 months of research conducted in the highlands of Northern Peru regarding medical treatment choice and health outcomes.

## Abstracts

A WOODLAND PETROGLYPH SITE IN LAMAR COUNTY. B. Bart Henson, Kenneth R. McDonald and Nina Jeffres, Alabama Archaeological Society, 7608 Teal Drive SW, Huntsville, AL 35802.

A petroglyph site has recently been discovered in northeast Lamar County, Alabama as a result of its exposure by heavy rains and the subsequent flooding condition of an adjacent stream. The petroglyphs are situated on an open sandstone bedrock and include nested diamonds, concentric circles, pit-and-grooves, multitudes of snakes, various meanders, a single small cross and an unusual highly complicated maze type feature exceeding one meter in length. Motifs were created by pecking, with the more elaborate features having been carefully smoothed.

Based upon an evaluation of motif style and content, and reported archaeological work by others in that area of the county, it is concluded that this petroglyph site has its origin in the Woodland Cultural Period.

MOUNDVILLE IV PHASE OF THE BLACK WARRIOR RIVER: A DEFINITION. Keith J. Little, Estate Gallery and Museum, Pensacola, Florida 32501. Caleb Curren, Pensacola Archeology Laboratory, Pensacola Junior College, Pensacola, Florida 32503.

Pottery of the protohistoric Moundville IV phase is described and the spatial and temporal ranges of the phase are delineated.

WEISS PHASE OF THE UPPER COOSA RIVER. Keith J. Little, Estate Gallery and Museum, Pensacola, Florida 32501.

Pottery of the protohistoric Weiss phase is described and the spatial and temporal ranges of the phase are delineated.



## Abstracts

THE CENTRAL AMERICAN AND AMAZONIAN FRONTIERS: SOME RETROSPECTIVE OBSERVATIONS ON DIFFERENTIAL HUMAN SETTLEMENT OUTCOMES. James Sewastynowicz, Department of Geography and Anthropology, Jacksonville State University, Jacksonville, AL 36265.

This paper describes the societal and individual-level impact of human settlement of two Latin American frontier zones, that of Costa Rica in Central America where the author has carried out ethnographic research since 1976, and the Amazonian frontier of South America. In the two areas, colonization processes and outcomes present certain parallels; for example, the negative ecological consequences that followed in the wake of uncontrolled forest destruction. Yet transcending any such similarities are the fundamentally opposite impacts these frontiers have had on their colonizers, and upon those who remained behind. In Costa Rica settlers, even formerly impoverished ones, often experienced real economic gains, and the frontier had the effect of sustaining a politically egalitarian national structure. In Amazonia, the frontier experience almost always entailed the reverse. This paper represents a preliminary attempt to uncover some of the factors responsible for these diametrically opposite settlement outcomes.

USE OF GROUND PENETRATING RADAR AT ARCHAEOLOGICAL SITES. Scott Shaw, Division of Archaeology, Alabama State Museum of Natural History, Univ. of Ala., 1 Mound State Monument, Moundville, AL 35474.

Due to a generous donation by the Transcontinental Gas Corporation of Houston, TX, the Division of Archaeology has acquired a ground penetrating radar system manufactured by Geophysical Survey Systems of North Salem, NH. The system is based on the propagation of high frequency electromagnetic waves into the soil and the recording of the reflected signal on graphic tape for instant viewing and/or magnetic tape for later computer analysis and playback. The images produced by the system represent anomalies in the earth such as soil interface zones, water tables, and artificially emplaced objects. The system only records the anomalies; it is the responsibility of the interpreter, with the aide of computer enhancement, to distinguish between natural and artificial anomalies. Although the Division of Archaeology has only been using the system for one month, it has proved successful at several sites. This paper will discuss the findings from sites such as Madison Hall on the University of Alabama campus, Capitol Park in Tuscaloosa, Mound State Park, and a possible cemetery in Mobile County.

## Abstracts

ARCHAEOLOGICAL SURVEY OF NORTHEAST ALABAMA. Curtis E. Hill, Department of Geography and Anthropology, Jacksonville State University, Jacksonville, AL 36265.

In 1989 and 1990, the Jacksonville State University Archaeological Resource Laboratory, through the support of the Alabama Historical Commission and the U.S. Department of the Interior conducted systematic archaeological surveys in a seven-county project area of northeast Alabama. Portions of Calhoun, Cherokee, Clay, Cleburne, Etowah, St. Clair and Talladega counties were surveyed. The primary goals of the surveys were to generate site locational and artifactual data while identifying and documenting regional archaeological resources. As a result of the 1989 and 1990 pedestrian archaeological surveys, 156 cultural resources were located and documented within the project areas. A substantial amount of artifactual materials were recovered indicating a temporal span from the transitional Paleo/Archaic Period through the historic Creek/Cherokee settlements. The archaeological data obtained from these and other similar surveys can only further enhance our knowledge of Alabama's rich and varied past.

DATA RECOVERY AT THE MOUNT WELCOME SITE, AN HISTORIC DANISH SUGAR PLANTATION ON ST. CROIX, U.S. VIRGIN ISLANDS. Catherine E. Clinton and Tim S. Mistovich, Panamerican Consultants, Inc, P.O. Box 050623, Tuscaloosa, Alabama.

On the island of St. Croix, remnants of 18th-19th century Danish sugar plantations can be seen on every hillside. The Mount Welcome Site is just one of hundreds of these sites. However, it represents the only plantation which has been studied in depth from an archaeological and historical perspective. Multi-disciplinary investigations at the Mount Welcome Site have provided invaluable information pertaining to subsistence, lifestyle, and economy, as well as a synchronic and diachronic reconstruction of plantation life on St. Croix, and the Caribbean basin in general.

RECENT EXCAVATIONS AT TANNEHILL FURNACE. Jeff Meyer, and Betsy Jones, Division of Archaeology, Univ. of Ala., Moundville, AL 35474

Iron from Tannehill furnaces supplied the daily demands of Alabama settlers and helped fuel the Confederate war machine. The burning of Tannehill in 1865 by a Union cavalry regiment ended a 35 year span which typified the ameliorization of the South's early iron industry. Excavations performed in August, 1990 by the University of Alabama's Division of Archaeology retraced the path of a mill sluice and uncovered a structure whose function changed as the ironworks evolved.

## Abstracts

TEST EXCAVATIONS AT DUST CAVE, 1990. Boyce N. Driskell, Alabama State Museum of Natural History, Univ. of Ala., University, AL 35487.

Following the finding of Middle Archaic deposits beneath a sterile overburden of cave collapse in Dust Cave during the summer of 1989, the Museum's Archaeology Division staff, assisted by students from the summer field school jointly sponsored by the University of Alabama, the University of North Alabama, and the Tennessee Valley Authority, returned during the summer of 1990 to more fully assess the cave's deposits. Dust Cave is one of numerous caverns found in the limestone bluffs on the north side of the Tennessee River near Florence, Alabama. The 1990 excavations revealed the presence of almost four meters of cave deposition with a stratigraphic sequence including Benton, Kirk, and Big Sandy components. A single fluted point was recovered near bedrock but it is not yet clear that these lowest deposits date to PaleoIndian times. The Museum will return to Dust Cave during the summer of 1991 to complete testing in the inner chambers of the cave.

OGLETREE ISLAND SITE, 1Ta238, A LAMAR SITE IN THE MIDDLE COOSA VALLEY. Richard Walling, Panamerican Consultants, Inc., P.O. Box 050623, Tuscaloosa, AL 35405.

The Ogletree Island site (1Ta238) is the northernmost site known to contain Kymulga complex ceramics. Although the material recovered from two field seasons had not been fully analyzed, Ogletree received a fair amount of attention in the archeological literature over the past several years. This interest was sparked by the recovery of a Nueva Cadiz Twisted bead from the floor of a burned aboriginal structure during the 1961 excavations. Though materials resulting from Archaic and Woodland occupations were also recovered, the major component resulted from a mid-Sixteenth century occupation. Results of the recent analysis are summarized. Emphasis is placed on the Contact period ceramics, artifacts of European manufacture, and on the integration of the site into the cultural framework presently being developed for the area.

CUISINE ZOOARCHAEOLOGY. Bill Grantham and Brian Hesse, Dept. of Anthropology, Univ. of Ala. at Birmingham, Birmingham, AL 35294-3350.

Ethnoarchaeological data developed from work among the Druze in the Golan Heights of the Levant are used to create a new model of animal resource valuation. Culturally distinct modes of slaughter selection, butchery practice, dish preparation and presentation, patterns labeled here "cuisines," create a set of values for carcass parts that contrasts with currently used models based on the anatomical distribution of meat. The zooarchaeological equivalents of this system are then applied to a sample drawn from Oazrin, a Byzantine - Early Islamic village, also located in the Golan.



## Abstracts

TOLBERT FARM, A LATE PALEO-EARLY ARCHAIC SITE COMPLEX NEAR JACKSONVILLE, ALABAMA. Harry O. Holstein, Department of Geography and Anthropology, Jacksonville State University, Jacksonville, AL 36265. Phillip Koerper, Department of History, Jacksonville State University, Jacksonville, AL 36265.

Tolbert Farm Complex is situated along a tributary branch of Tallasseehatchee Creek. These sites are of interest for two reasons: one, the density and diversity of Late Paleo/Early Archaic bifaces recovered from the Complex as compared to other regional Archaic sites; and two, the fact these sites lie nearly twenty miles east of the Coosa River along a small tributary branch. Researchers believe the geographical location of the Tolbert Farm Complex along Little Tallasseehatchee Creek, whose headwaters originate in White's Gap providing a major east/west entry across Choccolocco mountain, may explain the presence of this prolific early site complex.

FAUNAL ANALYSIS FROM DUST CAVE. Jennifer E. Grover, Dept. of Anthropology, University of Alabama, Tuscaloosa, AL. 35487-0210

Initial testing at Dust Cave (1LU496) in Lauderdale County, Alabama, has revealed undisturbed Early (12,000-8000 B.P.) and Middle (8,000-4,000 B.P.) Holocene deposits. The uniqueness of these deposits lies in the fact that they contain one of the most complete faunal records of the Early Holocene in the Middle Tennessee Valley. Given this, a research design has been proposed to measure the cultural response to the changing Early to Middle Holocene as reflected by changes in the climate, flora, fauna and demography.

SUBMERGED CULTURAL RESOURCE LEGISLATION DEVELOPMENT FOR THE STATE OF ALABAMA. Gregory C. Rhinehart, Alabama Historical Commission, 725 Monroe Street, Montgomery, AL 36130.

Development of Submerged Cultural Resource Legislation for the State of Alabama is a difficult process which must examine legislation, scientific principles, and philosophical differences between the professional maritime archaeologists and the marine salvors. The presentation highlights the efforts made to produce the legislation and the policies and procedures which must accompany it. The difficulties arising from the development of the policies and procedures are examined along with their interaction with the proposed legislation, any existing cultural resource legislation, and existing conceptions or beliefs regarding cultural resources as a whole.

## Abstracts

IN SEARCH OF DE LUNA'S COOSA. Harry O. Holstein, Jacksonville State University, Department of Geography and Anthropology, Jacksonville, AL 36265.

A test excavation was conducted at the Terrapin Creek Site, 1Ce309, Cherokee County, Alabama believed to be the location of the 16th Century Spanish contact site of Coosa. Excavation data proved Terrapin Creek Site was not Coosa. Pottery recovered resulted in redating the protohistoric Weiss Phase ceramics into the mid 16th Century. In turn, the reevaluation of several previously excavated Weiss Phase sites resulted in the discovery of a group of Weiss Phase sites around the confluence of the Chattooga and Coosa river who's geographical and archaeological data conforms succinctly with the ethnohistoric descriptions provided by the deLuna's chronicles

PROJECTILE POINTS OF CALHOUN COUNTY AND SURROUNDING COUNTIES.  
Angela Morgan, Jacksonville State University.

Calhoun County and the surrounding area offer an extensive and diverse wealth of lithic artifacts. Utilizing a small number of available bifacial points a stable typology can be determined which will give a better understanding of the different materials and methods which were used in production of the points. A sampling of one hundred forty-seven bifacial points have yielded forty-two independent style variations which employ a wide variety of available lithic resources and incorporate all phases of local aboriginal occupation of the area.

EXPERIMENTAL REPLICATION OF ABORIGINAL CERAMIC FIRING TECHNIQUES.  
Richard Bowman, Auburn University at Montgomery, Montgomery, Alabama 36193.

Recent controlled experiments have duplicated many aspects of the manufacturing, decorative, and firing techniques found on historic Creek ceramics from Central Alabama. For models, the experiments used archaeological sherds and vessels, and in one instance, raw clay from the 17th and 18th century Creek sites of Fusiatchee (1EE191), Kolomi (1MT3), Taskigi (1EE8), and Hickory Ground (1EE89). Among the more significant results were the determination of the probable techniques used in basic shaping, decoration, burnishing, firing, and reduction.

INTERPRETATION OF GARFISH SCALES FROM THE HAYNES BLUFF SITE, WARREN COUNTY, MISSISSIPPI. Chris S. McLaughlin, Dept. of Anthropology, University of Alabama at Birmingham, University Station, AL 35904.

The usual concern of zooarcheologists with the assessment of the relative dietary contributions of animal species found in assemblages from archeological sites may fail to fully accommodate the actual contributions of some species present. By comparing the relative frequencies of elements encountered within the assemblage with the expected frequencies of body parts from a whole animal of that species, a selection for certain body parts may be revealed. This selection may be for particular body parts of an animal which made little or no valuable dietary contribution.



MINUTES

ALABAMA ACADEMY OF SCIENCE/ALABAMA JUNIOR ACADEMY OF SCIENCE  
JOINT BUSINESS MEETING  
Holiday Inn, Oxford, AL  
March 8, 1991

1. Dr. Mike Lisano, President of AAS, called the meeting to order at 6:00 p.m.

2. The President asked for the report of the Counselor to AJAS, Dr. Eugene Omasta. The following written report was presented:

The Alabama Junior Academy of Science has a full schedule of activities planned for the annual meeting, including: the paper competition among 45 regional winners, tours, the caucus and the election of state officers, presentation of awards, the joint banquet, the disco dance, and a rap session with our speaker Dr. Charles Tolbert.

At this time, 195 students and teachers have pre-registered for the meeting.

3. The President called for the report of the Coordinator of Science Fairs. Ms. Rosie McKinney announced that all was going well.

4. The President called for the report of the Science Olympiad Coordinator. Dr. Steven Carey was not present to give a report.

5. The President called for the report of the Gorgas Foundation. Dr. Leven Hazlegrove, Chairman of the Judges of the Gorgas Scholarship Foundation, provided the following written report:

The Gorgas Scholarship Foundation announced today the ranking of the finalists in the 1991 Alabama Science Talent Search. The Search was held at the meeting of the Alabama Academy of Science at Jacksonville State University, Jacksonville, Alabama.

The winner of the first-place tuition grant of \$2500 was:  
Weily Soong, 2355 Tyrol Place, Vestavia Hills, AL 35216. Vestavia Hills High School. Peggy Patterson - Teacher.

First alternate and winner of a \$1500 tuition grant was:  
Munish Kumar Goyal, 2236 W. Aberdeen Drive, Montgomery, AL 36116. Sidney Lanier High School. John Halbrooks - Teacher.

Second alternate and winner of a \$1000 tuition grant was:  
Minna Miha Singh, 3806 Pasadena Avenue, Florence, AL 35630.  
Bradshaw High School. Rachel Speck Minor and Mary Nell Gonce - Teachers.

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Third alternate was:

Christopher Howard Inskeep, 122 Kensington Drive, Florence, AL 35633-1576. Bradshaw High School. Rachel Speck Minor and Mary Nell Gonce - Teachers.

Fourth alternate was:

Thomas Merrick Crittenden, 6474 Halcyon Drive, Montgomery, AL 36117. Sidney Lanier High School. Darin Carmichael - Teacher.

Fifth alternate was:

Samuel Lawson Houston, 2307 Quince Drive, Decatur, AL 35601. Decatur High School. Donald Johnston - Teacher.

Sixth alternate was:

Joel Hugh Linton, 523 Malone Circle, Florence, AL 35630. Bradshaw High School. Rachel Speck minor and Mary Nell Gonce - Teachers.

Seventh alternate was:

Danny Ryan Gray, Route 1, Box 154, Waterloo, AL 35677. Bradshaw High School. Rachel Speck Minor and Mary Nell Gonce - Teachers.

Eighth alternate was:

Alberto Pagan, 2411 Gawain Drive, Hoover, AL 35226. Berry High School. Mrs. Moon - Teacher.

Ninth alternate was:

Jason Thomas Byrnes, Route 7, Box 100A, Florence, AL 35630. Bradshaw High School. Rachel Speck Minor - Teacher.

Mr. Houston, Mr. Linton, Mr. Mankad, Mr. Crittenden, Ms. Countess and Mr. Soong were designated Semifinalists in the Westinghouse Science National Talent Search. Two Finalists, who won \$1,000 scholarships and a trip to Washington D.C. where President Bush spoke, were Mr. Mankad and Mr. Soong.

The following did not exhibit:

Edward Chung, 1773 Vestaview Lanae, Vestavia Hills, AL 35216. Vestavia Hills High School. Peggy Patterson - Teacher.

Karen Suzanne Countess, 982 Countess Road, Huntsville, AL 35810. Buckhorn High School. Mrs. Sandra Wilburn - Teacher.

Mehul Vipul Mankad, 5724 Vendome Drive South, Mobile, AL 36609. Saint Paul's Episcopal School. Peggy Wilkinson - Teacher.

The rankings were established by a panel of judges consisting of department heads, deans, and professors from many of the leading universities and industries in Alabama.

Dr. Leven S. Hazlegrove, Executive Director, Alabama Academy of Sciences, is Chairman of the Judges Committee.

Minutes

Winners and finalists in the Gorgas Contests receive offers of tuition scholarships to colleges and universities in Alabama for the study of science. The Gorgas Foundation is named for General William Crawford Gorgas, the Alabama physician who conquered yellow fever in the Panama Canal Zone and later became the Surgeon General of the U.S. Army. The purposes of the Foundation are to promote interest in science and to aid in the education of promising students.

6. The President called for the report of the Secretary. Ms. Debbie Folkerts presented the following report:

Membership, March 1990.....	912
Members deceased.....	-3*
New members added.....	167
Members dropped for non-payment of dues (Sept 30, 1990).....	-207
<hr/>	
Total membership, March 5, 1991.....	872
(net difference since March, 1990 = -40)	

- \*Dr. William H. Mason, Auburn University, Auburn, AL (AAS editor)
- Dr. Gilbert O. Spencer, Troy State Univ. (retired), Harvest, AL (past AAS president)
- Dr. E. Clifford Toren, University of South Alabama, Mobile, AL.

MEMBERSHIP BY SECTIONS

<u>Section</u>	<u>Dropped</u>	<u>Added</u>		<u>Total</u>
1 Biological Sciences	56	43	-13	238
2 Chemistry	23	21	-2	90
3 Geology	12	2	-10	41
4 For., Geog, Cons. & Plan.	9	1	-8	25
5 Physics and Mathematics	15	13	-2	96
6 Industry and Economics	18	10	-8	42
7 Science Education	6	13	+7	38
8 Social Science	7	8	+1	54
9 Health Sciences	42	22	-20	137
10 Engineering & Computer Sci.	7	18	+11	59
11 Anthropology	9	6	-3	21
99 (Undeclared or unknown)	3	10	+7	22

MEMBERSHIP BY TYPE

<u>Type</u>	<u>Present Number</u>
Individual	468
Student	69
Emeritus	22
Life	18
Honorary	6



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Sustaining indiv.	6
Sustaining org.	1
Unknown	273
Library	29
High School	50

Total Roster - 951

During registration for the meeting, 24 new memberships were added to the role, bringing the total membership to 896.

7. The President called for a report from the Executive Director. Dr. Leven Hazlegrove was present but did not wish to present an additional report.

8. The President then called for a report from the Place and Date of Meeting Committee. Dr. Elisabeth Sheldon was not present.

9. The President called for a report from the Research Committee. Dr. William Garstka announced the following:

Winners of the Research Awards for the following sections were selected by the Section and Session Chairpersons:

Biological Sciences:	Stephen P. Yanoviak	Auburn University
Chemistry:	R. Alan Davis	Auburn University
Geology:	Keith D. Pass	Auburn University
Physics & Mathematics:	Sihon Crutcher	Tuskegee University
Science Education:	Sue Robinson	Jacksonville St. U.
Engineering & Comp. Sci.:	Rustom Kersasp Vachha	UAB

Research Grants have been awarded by the Research Committee to the following students:

Marc Slattery	Biology - UAB
Chi-Ying Lee	Biology - UAB
Susila Dorai-raj	Biology - Auburn University
Steven VanWinkle	Geology - Auburn University
Vivek Anomulu	Computer Science - UAB
Zeki Bayram	Computer Science - UAB
V. Viswanathan	Computer Science - UAB
G. Keertinagar	Computer Science - UAB

## Minutes

Dr. Garstka also made several suggestions for changing procedures of the award competitions in the future. He suggested that information be sent to the chair of the Research Committee rather than to the section heads. This would allow the Research Committee to contact the students directly and avoid unnecessary delays. He also suggested that an additional space for abstracts be provided on the application forms. He also suggested that books purchased through the grant program become the property of the School or Department to which the student belongs.

This report and Dr. Garstka's suggestions were unanimously accepted.

10. The President called for a report from the Nominating Committee. Dr. Larry Boots provided the following information:

VicePresident.....PrakashSharma  
Tuskegee Univ.

Secretary.....Larry Boots  
UAB

Associate Counselors.....Betty Bigham  
to the Junior Academy Mary Montgomery High School

B.J. Bateman  
Troy State Univ.

Coordinator of State.....Steve Carey  
Science Olympiad Mobile College

Councilor of the AAAS.....James Henderson  
Tuskegee Univ.

### Trustees

(3 years)	Robert Gudauskas	Auburn Univ.
(3 years)	Dan Holliman	Birmingham Southern
(3 years)	Charles Baugh	USA
(3 years)	Wayne Finley	UAB
(2 years)	James Wilkes	Troy State Univ.

### Sections

I. Biological Sciences - Chairman: James McClintock, UAB  
Vice Chair: Steve Watts, UAB

VI. Industry & Economics - Chairman: Marsha Griffin, AL. A&M  
Vice Chair: Rick Lester, U.No.AL.

VIII. Social Sciences - Chairman: Lawrence Hanks, Tuskegee  
Co-Vice Chair: Dale Baskett, Tuskegee  
Co-Vice Chair: Richard Hudiburg, U.No.AL.

XI. Health Sciences - Chairman: George Tulli, Capstone Med. Ctr.  
Vice Chair: Mary Catherine Anderson, Troy

## Minutes

XI. Anthropology - Chairman: Boyce Driskell, Mound State  
Vice Chair: Harry Holstein, Jacksonville St.

11. The President called for a report from the Resolutions Committee. Dr. Linda Reed announced the following resolutions to be sent by the committee:

For appreciation of hospitality in hosting the 1991 meeting, Dr. H.J. McGee and Jacksonville State University; for his work in preparation for the 1991 meeting, Dr. Chris M. Horsfield; for passing officers, Dr. Mike Lisano and Ms. Debbie Folkerts; for deceased members, Dr. William H. Mason, Dr. Gilbert O. Spencer, Dr. E. Clifford Toren and Dr. Harold Wilson.

12. The President call for a report from the Scholarship Committee. Dr. Stan Jones was not present for a report.

There being no further business, the meeting was adjourned.



ENDANGERED PLANT SPECIES OF ALABAMA COASTAL PLAIN<sup>1</sup>

Michel G. Lelong  
Department of Biological Sciences  
University of South Alabama  
Mobile, AL 36688

INTRODUCTION

The first comprehensive listing of the rare plant species of Alabama was published in 1976 (Boschung, 1976). It was subsequently revised and expanded in 1979 (Freeman et al., 1979). In 1983, Dr. Freeman prepared and distributed another revised list of vascular plant species critical to maintenance of floristic diversity in Alabama in which he included 311 taxa (95 endangered, 91 threatened and 125 taxa of special concern). Forty-six additions and 16 deletions from the 1979 list of taxa were made. This revised list incorporated recent reports, particularly those of Kral (1983). Freeman noted that the Alabama flora probably includes close to 3,400 species and that, therefore, only 10% of these seem to be relatively rare. One hundred and fifteen of the 311 rare taxa of Alabama occur in the Coastal Plain region. Sixty-six (over 57%) of those grow in Mobile and/or Baldwin counties. In the following list, these species are grouped under six major plant communities in which they usually occur. Nearly three fourth of these rare coastal plants are plants of aquatic or wetland habitats, the rest occur in mesic woodlands or in dry pine-oak forests. The names of rare taxa are followed by letters in parenthesis indicating their status: endangered (E) for taxa in danger of extinction or extirpation from their range in Alabama; threatened (T) for taxa likely to become endangered in the State in the near future and "special concern" (SC) indicating taxa that are relatively rare in Alabama but not yet endangered or threatened. Taxa that have not been recently collected in Alabama and that are thought to be have become extirpated from the State are indicated by "EX?" The names of the Alabama counties in which the rare plant taxa have been collected are abbreviated following the taxa names.

Moist pinelands, flatwoods and bogs support by far the largest number (4) of rare plant species of Alabama Coastal Plain. Noteworthy among them are the Alabama pitcher plant (*Sarracenia rubra* subsp. *alabamensis*), known to occur in three counties of the Alabama Fall Line Hills, the black-eyed Susan *Rudbeckia nitida* collected only in Macon county and the beard grass *Andropogon arctatus* reported only from Covington county. *Lindera subcoriacea*, a rare spice bush was first

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<sup>1</sup>This article was presented as an invited paper at a Symposium on the Status of Endangered Species in Alabama on 9 March 1990 at the annual meeting of the Alabama Academy of Science held at Mobile College, Mobile Alabama.

described in 1983 by Dr. Wofford from a specimen collected on a hillside bog in George County, Mississippi, directly west of the Alabama state line. Bridges and Orzell (1989) collected it in 1989 in Mobile county in a nearby site.

The tropical American fern *Dicranopteris flexuosa* was collected once south of Mobile in 1913 and is believed to have been extirpated from this site (Wherry, 1964). *Rhynchospora crinipes*, a rare beak rush was known only from 2 collections made by Mohr near Mobile before the turn of the century. Recently, Anderson (1988) reported a number of his collections of this species from Santa Rosa county in western Florida. Ten other rare species of moist pinelands and bogs in Alabama Coastal Plain are known only from one county in the State as shown in the accompanying list. *Aristida simpliciflora* and *Rhododendron atlanticum* are assumed to occur in Alabama but no collections of those plants from the State have been recorded.

In 1984, the Alabama Natural Heritage Program prepared an initial prioritization of the State's natural heritage elements. They assigned ranking of one to four to 48 of Alabama's rare and endangered plant species. The rest were considered to be species of concern with poorly known status. Only three of the 40 rare species of moist pinelands and bogs were assigned priority rankings: the beard grass *Andropogon arctatus* (priority 4) known only in Alabama from Covington county; *Rudbeckia nitida* (priority 4), a black-eyed Susan collected in Macon only and the Alabama pitcher plant, *Sarracenia rubra* subsp. *alabamensis* (priority 3) endemic in seeps of the fall-line sandhills in three counties near the center of the State.

Twenty (ca 17%) of the rare plant species of the Alabama Coastal Plain occur in swamp and alluvial forests as shown in the accompanying table. Four species occur only in Houston county namely *Arnoglossum diversifolium*, *Sium floridanum*, *Solidago elliottii* and *Viburnum obovatum*. *Sium floridanum*, the water parsnip, is particularly noteworthy, being known from alluvial woodlands in only two other counties of southeastern United States, namely Jackson county, Florida and Miller county, Georgia (Kral, 1983). It was assigned a priority ranking of 3 by the Alabama Natural Heritage Program (1984) and is considered endangered in the State. *Lindera melissaefolia*, the swamp spicebush is also restricted to one county of Alabama, Wilcox county. Kral (1983) considers it one of our rarest shrub, recording it for only five counties in four southeastern States. The rare service berry holly, *Ilex amelanchier* was reported only for Mobile and Washington counties in the State by Freeman et al. (1979). I recently reported it for Baldwin county (Lelong, 1988b). It was assigned a priority rank of 4 by the Natural Heritage Program (1984) and is considered endangered in the State. The green-fly orchid, *Epidendrum conopseum*, the only epiphytic orchid to grow at our latitude has been collected only in 4 counties of Alabama's Coastal Plain. It seems to be somewhat more common at least in the swamps of the Mobile Delta than previously suspected and to occur on a greater diversity of hardwood trees, including live oaks, southern magnolias and swamp tupelos. It is considered endangered in the State.



## Endangered Plant Species of Alabama

Eighteen species (16%) of the 115 rare plant species of Alabama's Coastal Plain occur in marshes and lakes. Only two of those are assigned priority ranking (2), namely the meadow beauties, *Rhexia parviflora* and *R. salicifolia*. Kral (1983) reported discovering the first Alabama population of *R. parviflora* in 1981 in Geneva county. It was known previously only from Franklin county and perhaps also Liberty county, Florida, according to Dr. Kral. *Rhexia salicifolia* has been collected only in Covington and Houston counties, Alabama and in 6 counties of the Florida Panhandle. *Hibiscus coccineus* was recorded in the 1984 State list only for Covington county. I reported a 1980 collection of this rare plant from marshes along Dog River in south Mobile county (Lelong, 1988b). *Lilaeopsis carolinensis* was recently added to the State list, perhaps on the basis of a collection which I made in Baldwin county in 1980 (Lelong, 1988b). It should possibly be assigned an "Endangered" status in future State lists of rare plant species. The rare white arrow-*arum* *Peltandra sagittifolia*, previously reported only from Baldwin county in the State (Davenport and Haynes, 1981) was also collected in Mobile county (Lelong, 1988a). Jones (1974) documents its presence only in adjacent Jackson county in Mississippi.

*Trichlochin striata* (Arrow-grass), collected at the state of the century in brackish marshes at the mouth of Dog river in Mobile county was thought to be extirpated from coastal Alabama; it was recently collected in a tupelo swamp bordering Emanuel Bayou in Baldwin county (Lelong, 1988a).

Three species of marsh plants on our list are apparently not documented by recent collections from the Alabama Coastal Plain, namely *Cynosciadium digitatum*, *Kosteletzkya smilacifolia* (a questionable species), and *Thalia dealbata*.

Only six species of coastal aquatic vascular plants are included in the list of rare plant species in Alabama. *Myriophyllum laxum* was reported as endangered in the 1984 list; Dr. Kral reported it from Covington county in 1983 and one of my 1977 collections from big Creek Lake (Mobile county) was recently annotated as *M. laxum* by E. N. Nelson and R. W. Couch. I collected the rare pondweed *Potamogeton robbinsii* in 1970 in the lower Mobile delta. Dr. Haynes noted that this is only the second collection of this plant in the southeastern United States. The first report made in 1932 by Fernald was also based on a collection made in the Mobile delta. The nearest other known localities for this species are in Delaware. Four species of bladderworts (*Utricularia* spp.) occurring in south Alabama are considered threatened.

Rich mesic woods are possibly the least common type of plant communities, at least in coastal Alabama. They are mostly confined to a few undisturbed slopes and ravines along major rivers or their tributaries. Many of the plants occurring there are plants with northern affinity. Of the 16 plants on the accompanying list, only the attractive plumleaf azalea collected in three Alabama counties is assigned a priority rank (of 4) by the State Natural Heritage Program (1984). Other noteworthy plants of mesic woods include *Oenothera grandiflora*, collected



## Lelong

only in Baldwin and Sumter counties and *Orobanche uniflora* known only from 5 mostly northern counties; I collected it once in 1968 in Mobile county on a site which has since been cleared. *Sageretia minutiflora* is a typical calciphilic plant of coastal shell mounds and hammocks. It is most abundant on Little Dauphin Island and on Dauphin Island but also occurs sporadically on shell mounds in the Mobile Delta.

Only 15 of the 115 rare plants (less than 12%) in the Alabama coastal plain are plants of dry upland areas, growing in pine-oak forests, sandhills, coastal dunes and similar habitats. The only upland species in our list assigned a priority ranking is the big-leaf jointweed (*Polygonella macrophylla*), a rare dune plant often growing together with the other two (common) jointweed species, *P. gracilis* and *P. polygama*. *Polanisia tenuifolia* is another interesting dune plant restricted to Baldwin county in Alabama. Other rare upland plants which apparently do not grow west of Baldwin county are *Liatris chapmannii* and *Penstemon multiflorus*. *Oenothera heterophylla* is primarily a species of the western United States and was collected in three Alabama counties in the Black Belt. In 1974, Dr. Peter Raven informed me that he had collected it in 1967 in Mobile county north of Dog River. I searched in vain for it at this site but could not find it. It apparently did not persist there.

As shown clearly on the accompanying list, most of the rare plants of Alabama's coastal plain are wetland plants, especially those growing in moist pine savannas and bogs. The 1984 report of the Alabama Natural Heritage program included also a preliminary prioritization of unique geographical sites in each of the major physiographic provinces in the state. Pitcher plant bogs in Escambia county were assigned a priority rank of 1 along with the Escatawba river, the Styx river and Solider Creek in Baldwin county. The Mobile Delta, and the beaches and dunes along the Gulf of Mexico in Baldwin county were given a priority rank of 2. Other wetland sites in coastal Alabama were listed under priority 3 and 4.

Folkerts (1982) noted that "at least 97% of the former bogs which once extended continuously from Pensacola to Pascagoula have been destroyed or seriously altered" for a variety of reasons including drainage, fire prevention, urbanization and other departments. He mentioned also that "virtually no effort had been made to preserve some of the remaining bogs."

Since then, destruction of pitcher plant bogs, pine-oak savannas and other native coastal habitats has proceeded at an accelerated pace, particularly in expanding urban and industrial areas like Mobile and Gulf Shores. Fortunately a few of those valuable natural communities have been recently set aside in parks and refuges thanks largely to the effort of individuals in organizations like the Nature Conservancy, the Audubon Society, the Coastal Land Trust and numerous other groups in south Alabama dedicated to the preservation of fast disappearing natural areas. Hopefully, those successful efforts will continue and future generations will have the opportunity to enjoy and cherish our priceless natural heritage.

# Endangered Plant Species of Alabama

## RARE PLANT SPECIES OF ALABAMA COASTAL PLAIN

### I. Moist Pinelands, Savannas, Flatwoods, Bogs:

Taxon	Habitat	County Records
<i>Agalinis pseudaphylla</i>	SC	Bal., Esc.
<i>Andropogon arctatus</i>	E	Covington
<i>Aristida simpliciflora</i>	E	?
<i>Aster champmanii</i>	E	Gen., Hous.
<i>Aster eryngiifolius</i>	E	Cov., Gen., Hous.
<i>Cleistes divaricata</i>	T	Aut., Bal., Esc., Mob.
<i>Coelorachis tuberculosa</i>	SC	Bal., Cov., Gen.
<i>Coreopsis gladiata</i>	SC	Bal., Con., Cov., Gen. Hous., Mob., Wash.
<i>Dicranopteris flexuosa</i>	E(Ext)	Mobile
<i>Eriocaulon lineare</i>	SC	Bal., Cov., Esc., Gen., Hous., Lee(?), Mob.
<i>Eriocaulon texense</i>	SC	Esc., Mob., Wash.
<i>Hypericum nitidum</i>	T	Bal., Bibb, Dale, Gen., Hous., Mob., Tallap.
<i>Hypericum reductum</i>	SC	Bal., Mob.
<i>Kalmia hirsuta</i>	SC	Bal., Esc., Mob.
<i>Lindera subcoriacea</i>	E(?)	Mobile
<i>Panicum nudicaule</i>	T	Bal., Mob., Wash.
<i>Parnassia caroliniana</i>	E	Choctaw(?)
<i>Pinguicula planifolia</i>	SC	Bal., Gen., Hous., Mob.
<i>Pinguicula primuliflora</i>	SC	Bal., Gen., Mob., Wash.
<i>Platanthera integra</i>	SC	Bal., Mob.
<i>Pleea tenuifolia</i>	SC	Baldwin
<i>Psoralea simplex</i>	E	Mob., Wash.
<i>Quercus minima</i>	SC	Baldwin
<i>Quercus pumila</i>	SC	Gen., Hous., Mob.
<i>Rhexia aristosa</i>	SC	Barbour
<i>Rhododendron atlanticum</i>	E(Ext.)	?
<i>Rhynchospora crinipes</i>	E(Ext.)	Mobile
<i>Rudbeckia auriculata</i>	T	Bar., But., Cov., Gen., Pike, St. Clair

# Lelong

<i>Rudbeckia nitida</i>	E	Macon
<i>Sabatia brevifolia</i>	T	Baldwin
<i>Sabatia difformis</i>	SC	Geneva
<i>Sabatia quadrangula</i>	SC	Houston
<i>Sarracenia rubra</i>	T	Bal., Mob., Wash.
<i>Sarracenia rubra</i> ssp. <i>alabamensis</i>	E	Aut., Chil, Elm
<i>Sarracenia psittacina</i>	T	Bal., Cone., Cov., Esc., Mob., Wash.
<i>Schwalbea americana</i>	E	Bal., Gen., Mob.
<i>Selaginella ludoviciana</i>	SC	Bal., Cone., Crens., Hous., Mob., Monroe
<i>Xyris drummondii</i>	T	Bal., Cov., Gen., Mob., Wash.
<i>Xris longisepala</i>	SC	Cov., Hous.
<i>Xris scabrifolia</i>	T	Bal., Cone., Cov., Mob.

## II. Swamp Forests, Alluvial Woods, and Moist Woods:

Taxon	Habitat	County Records
<i>Arnoglossum diversifolium</i>	T	Houston
<i>Chamaecyparis thyoides</i> var. <i>henryae</i>	E(Ext.?)	Bal., Cone., Esc., Mob.
<i>Clethra alnifolia</i>	SC	Bal., Esc., Mon., Wash.
<i>Dryopteris ludoviciana</i>	SC	Cone., Cren., Houst.
<i>Epidendrum conopseum</i>	E	Bal., Cone., Hous., Mob.
<i>Fothergilla gardenii</i>	SC	Cov., Esc., Gen.
<i>Gentiana elliottii</i>	E	Cov., Dale, Gen., Hous., Lee(?), Tusc.
<i>Gordonia lasianthus</i>	T	Bal., Cov., Gen., Mob.
<i>Ilex amelanchier</i>	E	Bal., Mob., Wash.
<i>Juncus gymnocarpus</i>	T	Cov., Dale, Gen., Hous., Mob.
<i>Lilium iridollae</i>	E	Bal., Cov., Esc.
<i>Lilium superbum</i>	E	But., Esc., Gen., Hen., Hous., Lee, Macon, Sum., Tallap.
<i>Lindera melissaefolia</i>	E(Ext.)	Wilcox



## Endangered Plant Species of Alabama

<i>Pieris phillyreifolia</i>	T	Bal., Cov., Esc., Gen., Hous., Mob.
<i>Platanthera flava</i>	T	Bal., Mob. and other cos. in various provinces
<i>Rhapidophyllum hystrix</i>	T	19 CP counties
<i>Rhododendron austrinum</i>	SC	Clarke, Cof., Cone., Cov., Cren., Esc., Gen., Hous., Mob., Mon., Pike
<i>Sium floridanum</i>	E	Houston
<i>Solidago elliotii</i>	SC	Houston
<i>Viburnum obovatum</i>	SC	Houston

### III. Marshes, Lakes, Pond and Stream Margins:

Taxon	Habitat	County Records
<i>Acorus calamus</i>	T	Bal., Cal., Lime
<i>Aster pinifolius</i>	E	"Karst country of south- east Alabama" (Kral 1983)
<i>Canna flaccida</i>	T	Bal., Mob.
<i>Cynosciadium digitatum</i>	T	?
<i>Echinodorus parvulus</i>	SC	Gen., Hous
<i>Eustoma exaltatum</i>	SC	Bal., Mob.
<i>Hibiscus coccineus</i>	E	Cov., Mob.
<i>Kosteletzkya smilacifolia</i>	E	?
<i>Lilaeopsis carolinensis</i>	?	Baldwin
<i>Ludwigia arcuata</i>	T	Gen., Mob.
<i>Peltandra sagittaeifolia</i>	T	Bal., Mob.
<i>Rhexia parviflora</i>	E	Geneva
<i>Rhexia salicifolia</i>	T	Cov., Hous.
<i>Sabatia dodecandra</i> var. <i>foliosa</i>	SC	Bal., Mob., Wash.
<i>Sabatia grandiflora</i>	SC	Houston
<i>Sagittaria isoetiformis</i>	SC	Cov., Gen., Hous.
<i>Thalia dealbata</i>	E(Ext.?)	?
<i>Triglochin striata</i>	E	Bal., Mob.

IV. Aquatics:

Taxon	Habitat	County Records
<i>Myriophyllum laxum</i>	E	Bal., Cov., Mob.
<i>Potamogeton robbinsii</i>	E	Baldwin
<i>Utricularia floridana</i>	T	Cov., Mob.
<i>Utricularia inflata</i>	T	Gen., Mob.
<i>Utricularia purpurea</i>	T	Bal., Mob.
<i>Utricularia resupinata</i>	T	Covington

V. Mesic Forests, Hammocks:

Taxon	Habitat	County Records
<i>Athyrium thelypteroides</i>	T	?
<i>Baptisia megacarpa</i>	T	Elm., Gen., Lee, Macon, Mont., Tallap.
<i>Brickellia cordifolia</i>	T	But., Dale, Lee, Macon, Tusc.
<i>Carex baltzellii</i>	T	Dale, Gen., Hous.
<i>Celtis iguanaea</i>	T	Bal., Mob.
<i>Croomia pauciflora</i>	T	Chil., Choc., Clar., Co., DeKalb, Eto., Lee, Monr., Tallap., Tusc., Wilcox
<i>Matelea alabamensis</i>	E	Dale
<i>Oenothera grandiflora</i>	E	Bal., Sumter
<i>Orobanche uniflora</i>	SC	Blount, Cher., DeKalb, Mob., Tusc.
<i>Ponthieva racemosa</i>	SC	Clarke
<i>Rhododendron prunifolium</i>	E	Bar., Henry, Lee
<i>Sageretia minutiflora</i>	T	Bal., Mob.
<i>Schisandra coccinea</i>	E	Bibb, Clarke, DeKalb Mar., Morgan, Lawr., Sum.
<i>Stewartia malacodendron</i>	SC	15 cos. throughout AL, especially Coastal Plain
<i>Thelypteris hispidula</i> var. <i>versicolor</i>	SC	Bal., Henry, Lee, Mob., Pike, Wash.

## Endangered Plant Species of Alabama

<i>Thelypteris ovata</i>	SC	Clarke, Cone., Cov., Crens., Esc., Mob., Monroe, Sum., Wash.
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### VI. Upland Pine-Oak Forests, Sandhills, Dunes, Fields:

Taxon	Habitat	County Records
<i>Botrychium jenmanni</i>	SC	Bal., DeKalb, Lee, Mob.
<i>Croton elliotii</i>	E	Esc., Hous.
<i>Dyschoriste oblongifolia</i>	SC	Henry, Hous., Mob.
<i>Euphorbia discoidalis</i>	T	South Alabama counties
<i>Gentiana villosa</i>	E	Jef., Lee, Mob., Shelby
<i>Liatris chapmanii</i>	SC	Bal., Esc.
<i>Marsilea macropoda</i>	T	Mobile
<i>Oenothera heterophylla</i>	SC	Greene, Pickens, Sum.
<i>Penstemon multiflorus</i>	SC	Bal., Gen.
<i>Polanisia tenuifolia</i>	SC	Bal., Dale
<i>Polygonella macrophylla</i>	E	Baldwin
<i>Quercus arkansana</i>	SC	Aut., Chilton, Hale, Pike, Sum., Tusc.
<i>Rudbeckia mollis</i>	SC	Henry, Houston
<i>Tephrosia mohrii</i>	?	?
<i>Warea sessilifolia</i>	T	Pike

### LITERATURE CITED

- Alabama Natural Heritage Program. 1984. An initial prioritization of Alabama's natural heritage elements. 35 p. (mimeo.)
- Anderson, L. C. 1988. Status of endangered *Rhynchospora crinipes* (Cyperaceae). Systematic Botany 13(3): 407-410.
- Boschung, H., ed. 1976. Endangered and threatened plants and animals of Alabama. Bull. Alabama Mus. Nat. Hist. 2:1-12.
- Bridges, E. L. and S. L. Orzell. 1989. *Lindera subcoriacea* (Lauraceae) new to Alabama. Phytologia 67(3): 214-216.
- Davenport, L. J. and R. R. Haynes. 1981. Aquatic and marsh plants of Alabama II. Arecidae. Castanea 46: 291-299.



Lelong

- Fernald, M. L. 1932. The linear-leaved North American species of *Potamogeton*, section *Axillares*. *Mem. Amer. Acad. Arts* 17: 17.
- Folkerts, G. W. 1982. The Gulf Coast pitcher plant bogs. *Amer. Scientist* 70(3): 260-267.
- Freeman, J. D. 1983. Vascular plant species critical to maintenance of floristic diversity in Alabama. Alabama Natural Heritage Program. 23 p. (mimeo.)
- Freeman, J. D., A. S. Cauley, J. W. Short, and R. R. Haynes, eds. 1979. Endangered, threatened and special concern plants of Alabama. Agr. Exp. Sta. Dept. series no. 3, Auburn Univ., Auburn.
- Haynes, R. D. 1980. Aquatic and marsh plants of Alabama. I. *Alismatidae*. *Castanea* 45: 31-51.
- Jones, S. B., Jr. 1974. Mississippi Flora. I. Monocotyledon families with aquatic or wetland species. *Gulf Research Reports* 4(3): 357-379.
- Kral, R. 1983. A report on some rare, threatened, or endangered forest-related vascular plants of the South. Vols. 1 and 2. USDA Forest Service Tech. Pub. R8-TP2. 1305 p.
- Lelong, M. G. 1988a. Noteworthy monocots of Mobile and Baldwin counties, Alabama. *Sida* 13(1): 101-113.
- \_\_\_\_\_. 1988b. Noteworthy dicots of Mobile and Baldwin counties, Alabama. *Sida* 13(2): 223-240.
- Wherry, E. T. 1964. The southern fern guide. Amer. Fern Soc., New York Botanical Garden. 349 p.
- Wofford, B. E. 1983. A new *Lindera* (Lauraceae) from North America. *J. Arnold Arbor.* 64: 325-331.

COTTONTAIL RABBIT INITIAL RESPONSES TO  
PRESCRIBED BURNING AND COVER ENCHANCEMENT<sup>1</sup>

Sammy L. King and H. Lee Stribling  
Department of Zoology and Wildlife Science  
and Alabama Agricultural Experiment Station  
Auburn University, AL 36849

and

Dan Speake  
U. S. Fish and Wildlife Service  
Alabama Cooperative Wildlife Research Unit  
Auburn University, AL 36849

ABSTRACT

We investigated the initial responses of eastern cottontail rabbits (*Sylvilagus floridanus*) and vegetation to prescribed fire and cover enhancement practices. Prescribed fire was used to create 1 and 2 year old "roughs" (1YR or 2YR) by allowing vegetation to respond for 1 or 2 years following the fire. Pellet count analyses indicated that there were few differences between the size of cottontail populations on 1YR or 2YR, both with and without artificial cover enhancement. Descriptive comparisons indicated that pellet densities/unit area were greater on both burn treatment areas than on the unburned, unreplicated control. Vegetation analyses indicated few differences between the burn treatments, although yearly differences within similar treatments were often significant. Long-term research is needed to thoroughly evaluate cottontail responses to prescribed fire treatments.

Prescribed fire is a widely accepted silvicultural tool in southeastern forests with approximately 4 million acres burned annually (Lay 1967, Cooper 1965, Wade and Lunsford 1988). Fuel reduction, seedbed preparation, insect and disease control, and competition reduction are some of the benefits derived from prescribed fires (Wade and Lunsford 1988). In addition, prescribed burning generally enhances wildlife habitat and the aesthetic value of forests (Wade and Lunsford 1988), and therefore may represent a major component of multiple-use forest management plans. However, a greater knowledge of species-specific responses of animal populations to prescribed fire treatments is needed for the proper development and implementation of prescribed burning programs.

The eastern cottontail has been considered one of the most important game species in the United States (Chapman et al. 1982), attracting over 7.5 million hunters annually (U.S. Dept. of Interior 1982). Although prescribed fire has been recommended as a management tool for numerous upland wildlife species including the eastern cottontail (Rosene 1969,

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Hurst 1978, Hurst et al. 1980, Chapman et al. 1982), fire's effect on cottontail populations has not been thoroughly investigated (Hill 1981). Increased quantity and quality of forage produced by prescribed fire treatments (Harlow and Bielling 1961, Lewis et al. 1967, Speake et al. 1975, Buckner et al. 1979) may enhance cottontail reproduction (Hill 1981); however, Heard (1962) noted a decrease in cottontail production which he credited to the widespread loss of cover following a fire on his study area.

Distribution of suitable food and cover can directly influence cottontail survival and home range size (Trent and Rongstad 1974) and indirectly affect cottontail abundance (Edwards et al. 1981). Cottontail populations are regulated by survival dependent mechanisms (Edwards et al. 1981) and management should be directed at increasing adult survival (Chapman et al. 1982).

Adding artificial brush piles can increase cottontail densities (Dalke 1942, Haugen 1943, Madson 1963), but their effectiveness following prescribed fires has not been evaluated. Similarly, the prescribed fire frequency which provides the most benefits and least detriments to cottontail populations also is unknown and warrants further study (Hill 1981).

The objectives of this study were to: 1) compare rabbit densities between areas with 1 or 2 year old "roughs" created by prescribed burning, with and without artificial cover enhancement, and 2) determine and compare vegetation responses to the prescribed fire and regrowth treatments and attempt to relate these responses to cottontail population densities.

#### STUDY AREA AND METHODS

We conducted our study at the Piedmont Substation of the Alabama Agricultural Experiment Station. The 569-ha substation is located in Tallapoosa County and lies within the Piedmont physiographic region. The station contains 800 ac of forested areas of predominately mixed pine/hardwood, with the remaining 600 ac divided among fruit tree orchards, seed tree orchards, shade tree trials, and pastures. Soils are predominately clay loams of the Appling, Cecil, and Gwinnett types (Hajek et al. 1975).

Major overstory species of the woodlands include loblolly pine (*Pinus taeda*), sweetgum (*Liquidambar styraciflua*), yellow poplar (*Liriodendron tulipifera*), southern red oak (*Quercus falcata*), and a variety of other oak (*Quercus* spp.) and hickory (*Carya* spp.) species. Midstories are composed of the above species, as well as flowering dogwood (*Cornus florida*), green briar (*Smilax* sp.), wild grapes (*Vitis* sp.), yellow jessamine (*Gelsemium sempervirens*), and honeysuckle (*Lonicera japonica*). Broomsedge (*Andropogon virginicus*), sassafras (*Sassafras albidum*), panicums (*Panicum* sp.) and a variety of tree seedlings and grasses represent the major understory species. Fields surrounding the woodlots contain various combinations of rye (*Secale cereale*), ryegrass



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(*Lolium* sp.), crimson clover (*Trifolium pratense*), alfalfa (*Medicago sativa*), fescue (*Festuca* spp.), bahaigrass (*Paspalum notatum*), and dallisgrass (*Paspalum dilatatum*).

Five areas, approximately 80 acres each, were chosen from the forested areas and designated for intensive study. Two areas were randomly designated to be 1 year old "roughs" (1YR) and were burned on an annual basis. Two areas were randomly designated to be 2 year old "roughs" (2YR) and were burned and then allowed to grow for 2 years. In addition, immediately following a burn, one-half of each area was randomly chosen to receive artificial cover (AC) enhancement in the form of loosely piled brush at the rate of 1 brush pile per acre. Brush piles, which were approximately 15 ft in diameter, were fertilized with 13-13-13 at the rate of 400 lbs per acre to encourage herbaceous growth for forage and cover. The remaining area received neither burning or cover treatments (no burn and no cover, NBNC). Therefore, the basic study design was a split-plot (2 treatments and 2 replications) and an untreated, unreplicated control used for comparative purposes.

All study areas excluding the control were burned initially during the winter (February 10 - March 25) of 1987. The 1YR areas received a second prescribed burn between 7-17 March 1988 to maintain the "roughs" on these areas in a first year growth. The 2YR areas were allowed to remain unburned in 1988 to produce the 2 year old "rough" vegetation stage.

### Pellet Counts

Each area contained 2-4 transect lines of variable length. The length of each transect line and the distance between adjacent lines varied according to the size and shape of the area, however all transect lines were greater than 150 ft apart.

Cottontail pellet groups (Litvaitis et al. 1985, Fuller and Heisey 1986) were counted in the fall (November - December) and winter (February-March) of each year. Winter pellet count surveys were completed prior to winter burning. Transect lines were traversed seasonally and all pellet groups within 1.6 ft (0.5 m) of either side of the transect line were recorded. Pellets further than 3.3 ft (1 m) from adjacent pellets were considered a separate pellet group. All data were collected according to experimental design, except for the initial count at the beginning of the study which accounted only for the main effects (vegetation response to burning frequency) within each area.

Total pellet groups/unit area were calculated for each subplot unit and statistically compared (Proc ANOVA; SAS Institute 1987) for treatment and seasonal differences. A least squares means test was used to identify differences among pellet density means (Proc GLM; SAS Institute 1987).

### Vegetation Analysis

Vegetation analyses were conducted from October - December 1986, August - October 1987, and August - September 1988. Several habitat variables were measured at plots centered at 164 ft (50 m) intervals along

the previously described transect lines. Leaf litter and legume (0 - 3.9 ft in height) cover within a 3.3 ft (1 m) diameter circle from plot center were determined by ocular estimates. Midstory stem (4 - 20 ft. in height; < 2.5 in dbh; 33 ft diameter circular plots) density and the basal area of overstory (> 20 ft in height; > 2.5 in dbh; 33 ft diameter circular plots) species were also determined. A spherical densiometer (Lemmon 1957) was used to measure percent canopy closure, while estimates of horizontal cover density were made at 16 (5m) and 49 ft (15 m) from the 4 cardinal points around the plot center using a modified density board (Nudds 1977) which was 7 ft and divided into 4 equal sections of 1.75 X 1.5 ft. Averages of the 16 and 49 ft estimates for each of the 4 sections were used in statistical analyses.

Means of all habitat variables were calculated (Proc MEANS; SAS Institute 1985) for each area and comparisons (Proc GLM; SAS Institute 1987) were made to test for differences between years and treatment. Means were separated by Duncan's multiple range test. Arcsin transformations were used for canopy closure and horizontal density data because of non-normality.

## RESULTS

### Pellet Densities

Pellet count analyses indicated significance for season ( $P = 0.011$ ) and burn/cover interactions ( $P = 0.008$ ). Winter pellet densities on 2YR were the greatest densities observed during the study, and were significantly greater than fall pellet densities in either 1YR ( $P = 0.017$ ) or 2YR ( $P = 0.012$ ) study areas (Table 1).

Table 1. Mean seasonal pellet densities ( $1 \times 10^{-2}$  pellet groups/3.3 ft<sup>2</sup>) on areas subjected to different burning and cover regimes on the Piedmont Agricultural Substation, Camp Hill, Alabama, 1986-1988.

	Fall	Winter
1 Year "Roughs" <sup>1</sup> (1YR)	1.1 (0.7) A	1.6 (0.4) AB
2 Year "Roughs" (2YR)	1.1 (0.2) A	2.2 (0.5) B
No Burn <sup>2</sup> (NB)	0.8 (0.5)	0.7 (0.1)
Artificial Cover (AC)	0.9 (0.2) a	1.8 (0.5) ab
No Cover (NC)	1.1 (0.2) ab	2.0 (0.3) b

<sup>1</sup>Means sharing a letter are not significantly different ( $P > 0.05$ ). Upper case letters indicate seasonal comparisons for burn treatments. Lower case letters indicate seasonal comparisons for cover treatments.

<sup>2</sup>Statistical analyses were not conducted.

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Within a season, pellet densities were greater on areas that had no additional cover provided. Winter no cover (NC) pellet densities were significantly greater ( $P = 0.024$ ) than fall pellet densities on areas which had artificial cover (AC) added, although there was no significance difference ( $P \leq 0.05$ ) between cover treatments for similar seasons. This difference may reflect the greater importance of seasons compared to cover in determining pellet densities on a given area.

2YR-AC and 1YR-NC treatments supported the greatest pellet densities among the burn/cover treatments (Figure 1). The lowest mean pellet densities ( $\bar{x} = 0.008/3.3 \text{ ft}^2$ ) occurred on 1YR-AC treatments, and were significantly less than 1YR-NC ( $P = 0.020$ ) and 2YR-AC ( $P = 0.014$ ). Significant differences were not observed between any other treatment types.

Initially, the NB area supported greater mean pellet densities than the 1YR or 2YR treatments. However, mean pellet densities on the NB area declined after the fall 1987 census and mean pellet densities on the 1YR and 2YR treatments exceeded those of the NB area in all subsequent censuses.

### Vegetation Results

Vegetation analyses indicated most habitat variables did not differ according to treatment (Table 2), however 2YR treatments supported a greater amount of cover from 0.0 - 3.50 ft (0 - 1.75 ft --  $P < 0.001$ ; 1.76 - 3.50 ft --  $P = 0.008$ ) above ground level and lower percent canopy closure ( $P = 0.002$ ) than did 1YR treatments. No other variables exhibited significant ( $P \geq 0.05$ ) treatment differences.

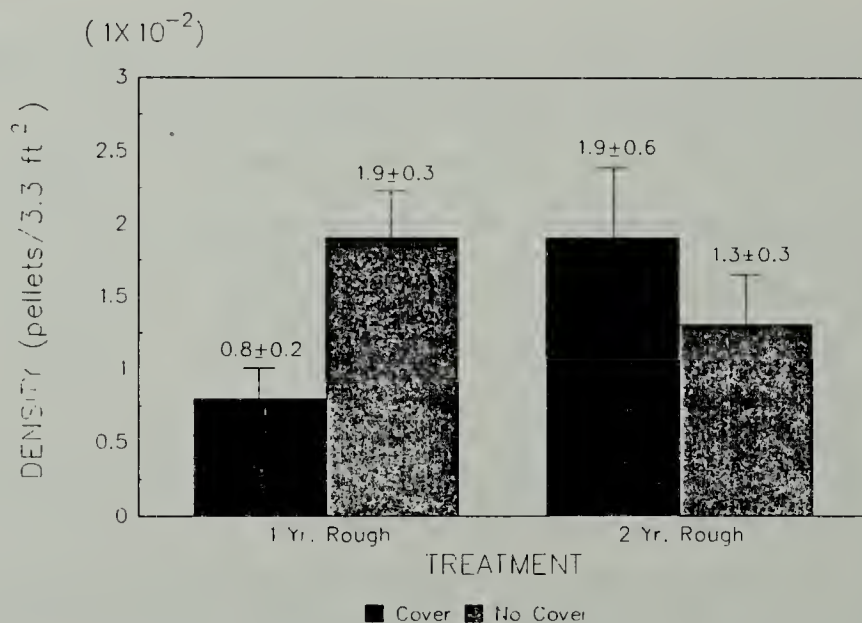


Figure 1. Mean pellet densities in 1 and 2 year "roughs," with and without artificial cover enhancement, on the Piedmenot Agricultural Substation, Camp Hill, Alabama, 1986-1988.



Table 2. Mean yearly vegetation values for 1 and 2 year old "roughs" and unburned treatments areas on the Piedmont Agricultural Substation, Camp Hill, Alabama, 1986-1988.

	1 Year Rough (1YR)		2 Year Roughs (2 YR)		Unburned (UB)		
	1986	1987	1988	1986	1987	1988	1988
% Understory Cover	8.0 A <sup>1</sup>	34.1	28.6	19.5 a	30.5 b	37.8 b	28.2
% Canopy Closure <sup>2</sup>	77.8 A	93.5 B	86.0 C	81.6 a	84.3 b	80.1 a	93.2
% Leaf Litter	80.1 A	63.6 B	70.6 C	83.0 a	67.9 b	70.1 b	74.2
Midstory Stem Density	54.7 A	43.5 A	29.2 B	37.7 b	55.3 b	34.4 b	38.5
% Legume Coverage	0.1 A	4.0 B	1.7 C	0.0 a	3.5 b	2.2 b	2.8
% Horizontal Cover Density 0.00-1.75ft <sup>3</sup>	44.8 A	61.3 B	44.1 A	64.6 a	61.4 ab	56.0 b	60.4
1.76-3.50ft <sup>3</sup>	42.9 A	53.2 B	31.7 C	63.0 a	45.9 b	41.4 c	51.2
3.51-5.25ft	43.1 A	51.8 B	33.0 C	59.3 a	40.1 b	35.1 b	52.4
5.26-7.00ft	42.8 A	50.9 A	30.7 B	54.9 a	34.0 b	29.3 c	49.2

<sup>1</sup> Means sharing a letter within a row are not significantly different ( $P > 0.05$ ). Yearly comparisons were made within treatments only. Uppercase letters were used for comparisons between years of 1 YR treatment and lower case letters were used for comparison between years of 2YR treatment.

<sup>2</sup> Indicates that pooled yearly values for % canopy closure for 1YR treatment are significantly greater than 2YR treatment means ( $P < 0.05$ ).

<sup>3</sup> Indicates that pooled yearly values for one of the 2YR % horizontal cover density levels are significantly greater than those of the 1YR treatment means ( $P < 0.05$ ).

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Yearly differences within treatments were often significant ( $P < 0.05$ ) for many habitat variables. On both treatment types, percent legume coverage increased significantly following the 1987 burn treatment, although following the winter burn of 1988, a significant decline in percent legume coverage on 1YR areas was observed. A similar but non-significant decline was observed following the absence of fire on 2YR treatment areas.

Percent understory coverage also increased significantly from initial values for both treatment types. On both treatment types, initial values were less than 20%, however following the winter burn of 1987 values exceeded 30% for both treatments. A slight, non-significant decline was observed on 1YR treatment areas in 1988, while a slight, non-significant increase was observed on the 2YR treatment areas.

Responses of horizontal cover density varied among the 1YR and 2YR treatments. On 1YR treatments, cover density increased significantly from 0.0 - 7 ft in 1987, with significant increases over pre-burn values for cover densities located 0.0 - 3.50 ft above ground level. In 1988 however, significant declines were observed at all levels. The significant increases on 1YR plots in 1987 contrasted with results from 2YR areas. Significant declines were observed in 1987 on 2YR treatments, and further non-significant declines were observed in 1988 at all measured levels.

Leaf litter coverage did not differ significantly ( $P = 0.27$ ) in response among treatments with the greatest values being recorded in 1986. Significant declines were observed on both treatments in 1987, although values increased significantly on 1YR treatments in 1988.

Analyses of vegetation variables on the NB study area indicated similar yearly trends. All measured variables increased from initial values, with horizontal cover density measurements and midstory stem densities exceeding values obtained for both burn treatments during all years. Legume coverage and percent understory coverage on NB were lower than values from burned areas.

## DISCUSSION

It is generally believed that any prescribed burning regime is more beneficial to cottontails than fire exclusion, although the burning frequency which provides the most benefit to cottontails is unknown (Hill 1981). Results of this study suggest few differences between cottontail responses to 1 year old "roughs" versus 2 year old "roughs", with or without artificial cover enhancement.

Descriptive comparisons between the burned and unburned areas suggest roughs (1YR or 2YR) resulting from prescribed burning may enhance cottontail populations in the Piedmont of Alabama. However, the unburned area was not replicated and the results were not statistically analyzed. Therefore, these results must be interpreted cautiously.

It is also important to note that differences in pellet visibility among the burned and unburned treatment areas may have also affected pellet density estimates. These effects are believed to be minimal however, because pellet counts were conducted following the fall senescence of vegetation which tended to equalize visibility on all areas.

Seasonal pellet count differences among 1YR and 2YR treatments may have been related to the timing of sampling in relation to leaf fall. Fall censuses were conducted immediately after leaf fall, which may have reduced the number of visible pellets (Fuller and Heisey 1986). Additionally, there was a greater amount of time between leaf fall and the winter census than between leaf fall and the fall census, which may have allowed for a greater period of cottontail activity prior to leaf fall, and hence the deposition of a greater number of pellets which would be visible to the investigator during the winter census. Because of these differences, the most important comparisons were between treatments within similar seasons. These comparisons indicated no significant differences existed among the treatment types.

Post-burn increases in legume and understory production were not unexpected, and have been reported by numerous investigators for a variety of habitat types throughout the Southeast (Harlow and Bielling 1961, Lewis et al. 1967, Speake et al. 1975, Buckner et al. 1979). The moist heat produced by fires stimulates germination of legume seeds (Martin and Cushwa 1966) and reduces competition from other species (Komarek 1971, Landers 1981). Maximum germination of leguminous seeds requires exposure to a certain threshold temperature which may not be reached by fires of low intensity (Martin and Cushwa 1966). Therefore on the 1YR treatment areas, lower pre-burn values for leaf litter in 1987 as opposed to those of 1986 may have produced the patchy, low intensity burns observed in 1988 and brought about the significant decline in legume coverage later that year. However, further long-term research is needed to evaluate this relationship.

The lack of significant differences observed for most other habitat variables between the various treatment types were not unexpected considering the fire history of the study area. Fires were virtually excluded from all study areas for a period of at least 30 years before initiation of this study. In the prolonged absence of fire, annuals and other desirable herbaceous species are virtually eliminated by competition, and repeated fires and a considerable amount of time is required to restore original vegetative communities (Cushwa and Redd 1966, Cushwa et al. 1970, Komarek 1974:268-269). Our study areas had not yet been subjected to a well established burning program, as initial burns were not conducted until 1986.

These conditions were further complicated by the severe drought experienced from 1986-1988. Mean annual rainfall for this period ranged from 22 - 54 in below the 100 year averages, and may have reduced the potential benefits gained by annuals and other herbaceous plants from a prescribed burning program. As a direct result, cottontail population responses to the various treatments may have also been affected. Hill



## Cottontail Rabbit

(1972) noted extended summer drought may disrupt cottontail reproduction in Alabama because of the lack of succulent vegetation to meet reproductive needs. However, the effects of drought on cottontail production and on vegetative responses following prescribed fire treatments in the Piedmont warrants further study.

### MANAGEMENT IMPLICATIONS

Results from this study suggest few differences among cottontail responses in the Piedmont of Alabama to 1YR and 2YR produced by prescribed fire, both with and without cover enhancement. However, the results may indicate that habitat present, whether it is that produced in the first or second year following a prescribed fire, is more beneficial to cottontails than total fire exclusion. Forest managers should not expect immediate increases in cottontail densities and/or vegetative communities following 1 or 2 prescribed fires after prolonged fire exclusion. Further study is needed to evaluate the long-term effects of various burning regimes on cottontail rabbit populations.

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### LITERATURE CITED

- Buckner, J. E., J. L. Landers, J. A. Barker, and C. J. Perkins. 1979. Wildlife food plants following preparation of longleaf pine sites in southwest Georgia. *South. J. Appl. For.* 3:56-59.
- Chapman, J. A., J. G. Hockman, and W. R. Edwards. 1982. Cottontails. Pages 83-123 in J. A. Chapman and G. A. Feldhammer, eds. *Wild Mammals of North America: Biology, Management, Economics*. John Hopkins Univ. Press, Baltimore, MD.
- Cooper, R. W. 1975. Prescribed burning. *J. For.* 73:776-780.
- Cushwa, C. T., and J. B. Redd. 1966. One prescribed burn and its effects on habitat of the Powhatan Game Management Area. *Southeast. For. Exp. Sta., U.S. For. Serv. Res. Note SE-61*. 2pp.
- \_\_\_\_\_, M. Hopkins, and B. S. McGinnes. 1970. Response of legumes to prescribed burns in loblolly pine stands of the South Carolina Piedmont. *Southeast. For. Exp. Sta., U.S. For. Serv. Res. Note SE-140*. 6pp.

- Dalke, P. D. 1942. The cottontail rabbit in Connecticut. Bull. Connecticut Geol. Nat. Hist. Surv. 65:1-97.
- Edwards, W. R., S. P. Havera, R. F. Labisky, J. A. Ellis, and R. E. Warner. 1981. The abundance of cottontails (*Sylvilagus floridanus*) in relation to agricultural land use in Illinois (U.S.A.), 1956-1978, with comments on mechanisms of regulation. Pages 761-789 in K. Myers and C. D. MacInnes, eds. Proc. World Lagomorph Conf. Guelph, Ontario.
- Fuller, T. K., and D. M. Heisey. 1986. Density-related changes in winter distribution of snowshoe hares in Northcentral Minnesota. J. Wildl. Manage. 50:261-264.
- Hajek, B. F., F. L. Gilbert, and C. A. Steers. 1975. Soil associations of Alabama. Auburn Univ. Agric. Exp. Stat. and U. S. Soil Cons. Serv. Agron. and Soils Dept. Ser. No. 24. 30pp.
- Harlow, R. F., and P. Bielling. 1961. Controlled burning studies in longleaf pine-turkey oak association on the Ocala National Forest. Proc. Annu. Conf. S.E. Assoc. Game and Fish Comm. 25:18-46.
- Haugen, A. O. 1943. Management studies of the cottontail rabbit in southwestern Michigan. J. Wildl. Manage. 7:102-119.
- Heard, L. P. 1962. Job completion report, rabbit studies (cottontail). Pittman-Robertson Proj. W-48-R-8, Mississippi. 25pp.
- Hill, E. P., III. 1972. The cottontail rabbit in Alabama. Auburn Univ., Agric. Exp. Stn. Bull. 440. 103pp.
- \_\_\_\_\_. 1981. Prescribed fire and rabbits in southern forests. Pages 103-108 in G. W. Wood, ed. Prescribed Fire and Wildlife in Southern Forests. Belle W. Baruch For. Sci. Inst. of Clemson Univ., Georgetown, S.C.
- Hurst, G. A. 1978. Effects of controlled burning on wild turkey poult food habits. Proc. Ann. Conf. S. E. Assoc. Fish and Wildl. Agen. Annu. Conf. 32:30-37.
- \_\_\_\_\_, J. T. Campo, and M. B. Brooks. 1980. Deer forage in a burned and burn-thinned pine plantation. Proc. S.E. Assoc. Fish and Wildl. Agen. Annu. Conf. 34:476-481.
- Komarek, E. V., Sr. 1971. Effects of fire on wildlife and range habitats. Pages 46-53 in Proc. Prescribed Burning Symposium. U.S.D.A. For. Serv., Southeast. For. Exp. Sta., Charleston, S. C.
- \_\_\_\_\_. 1974. Effects of fire on temperate forests and related ecosystems: Southeastern United States. Pages 251-277 in T. T. Kozlowski, and C. E. Ahlgren, eds. Fire and Ecosystems. Academic Press, New York. 542pp.

## Cottontail Rabbit

- Landers, J. L. 1981. The role of fire in bobwhite quail management. Pages 73-80 in G. W. Wood, ed. Prescribed Fire and Wildlife in Southern Forests. Belle W. Baruch For. Sci. Inst. of Clemson Univ. Georgetown, S. C. 170pp.
- Lay, D. W. 1967. Browse palatability and the effects of prescribed burning in southern pine forests. J. For. 65:826-828.
- Lemmon, P. E. 1957. A new instrument for measuring forest overstory density. J. For. 55:667-668.
- Lewis, J. B., D. A. Murphy, and J. Ehrenreich. 1967. Effects of burning dates on vegetation production on Ozark forests. Proc. Annu. Conf. Southeast. Assoc. Game and Fish Comm. 18:63-72.
- Litvaitis, J. A., J. A. Sherburne, J. A. Bissonette. 1985. Influence of understory characteristics on snowshoe hare habitat use and density. J. Wildl. Manage. 49:866-873.
- Madson, J. 1963. The cottontail rabbit. Second edition. Olin Mathieson Chemical Corp., East Alton, Ill. 55pp.
- Martin, R. E., and C. T. Cushwa. 1966. Effects of heat and moisture on leguminous seed. Proc. Tall Timbers Fire Ecol. Conf. 5:159-175.
- Rosene, W. 1969. The Bobwhite Quail: Its life and management. Rutgers Univ. Press, New Brunswick, New Jersey. 418pp.
- SAS Institute Inc. 1985. SAS procedure guide for personal computers. Version 6 ed. SAS Institute, Inc. Cary, N. C. 373pp.
- \_\_\_\_\_. 1987. SAS/STAT guide for personal computers. Version 6 ed. SAS Institute, Inc. Cary, N. C. 1028pp.
- Speake, D. W., E. P. Hill, and V. E. Carter. 1975. Aspects of land management with regard to production of wood and wildlife in the southeastern United States. Pages 333-349 in B. Bernier and C. H. Winget, eds. Forest soils and forest land management, Proc. 4th N. Amer. Forest Soils Conf.
- Trent, T. T., and O. J. Rongstad. 1974. Home range and survival of cottontail rabbits in southwestern Wisconsin. J. Wildl. Manage. 38:459-472.
- Wade, D. D., and J. D. Lunsford. 1988. A guide for prescribed fire in southern forests. U. S. Dept. of Agric., Forest Serv., Southern Region. Tech. Publ. R8-TP 11. 56pp.



A WOODLAND PETROGLYPH SITE IN LAMAR COUNTY<sup>1</sup>

B. Bart Henson, Kenneth R. McDonald and Nena Jeffreys  
*Alabama Archaeological Society*  
7608 Teal Drive SW  
Huntsville, AL 35802

ABSTRACT

A petroglyph site has recently been discovered in northeast Lamar County, Alabama, as a result of its exposure by heavy rains and the subsequent flooding condition of an adjacent stream. The petroglyphs are situated on an open sandstone bedrock and include nested diamonds, concentric circles, pit-and-grooves, multitudes of snakes, various meanders, a single small cross and an unusual, highly complicated maze type feature exceeding one meter in length. Motifs were created by pecking, with the more elaborate features having been carefully smoothed.

Based upon an evaluation of motif style and content and reported archaeological work by others in that area of the county, it is concluded that this petroglyph site has its origin in the Woodland Cultural Period.

INTRODUCTION

This report documents through photographs and drawings a remarkable petroglyph site in northeast Lamar County, Alabama. Its fortuitous discovery by McDonald and Jeffreys was made possible by flood water exposure of a few square inches of what ultimately proved to be a large, one of a kind, maze-type glyph and numerous other small glyphs which appear to have remained unaltered since their creation by aboriginal artists.

The site consists of a large number of randomly placed individual petroglyphs formed by pecking with a pointed tool on an essentially level sandstone bedrock formation. The area encompassing the features is approximately 6 x 8 meters and is peripheral to a small, normally dry branch. The bedrock exposure lies in the transition zone between the first terrace above the Buttahatchee River and its flood plain. At this location the branch makes a rapid transition from the adjacent hilly area and passes the site. A few meters downstream from the site it makes a precipitous descent into a gorge leading to the river, which is perhaps 100 meters distant.

The long axis of the principal feature, the "maze," is orientated approximately in the E-W direction, while the main body of the site lies generally in the N-S direction.

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A site of this nature may be expected to have had a population center nearby and, indeed, such a population could have lived abundantly and comfortably. This area of the state presently has an annual rainfall of 52 inches and is drained by the Buttahatchee River which flows 532 cubic feet per second in the vicinity of the site (Pierce and Geurin, 1959). Fish and game quantities along the margin of the river, supplementing the already established agricultural base, would have been favorable for supporting a substantial population. The climate is temperate, with the summers long and humid.

The availability of raw material for tools may also have influenced the aboriginal occupants to live in the area. Practically "the entire surface of Lamar County is covered by the gravels, sands and clays of the Tuscaloosa formations" (Semmes, 1929). In the Northeastern part of the county the Buttahatchee River has cut through the strata to the upper Cretaceous Tuscaloosa formation which exposes multicolored clay, sand and gravel (Carlston, 1944). Further, the terrain is loamy and has a gravelly subsoil which is formed into unconsolidated beds of marine sediments which consist of silt, clay and gravel (Soil Survey of Marion County Alabama, 1975). It is precisely these gravel beds which have been so important in the lithic tool technology of the area (DeJarnette et al., 1975a). It is also the author's observation that red and yellow chert pebbles dominate the creek beds and road cuts and are abundant wherever the soil is exposed.

#### METHODS

After having made the initial discovery of a few square inches of the maze feature, the entire feature was exposed by removing the thin layer of silt and topsoil by hand (Figure 2). Thus revealed, the existence of a much larger and significant petroglyph site was immediately suggested. A plan was developed to uncover, map and photograph additional features which might exist. After one day of carefully removing topsoil by hand and brush (shovels would have scraped the rock surface), a faster and less labor intensive method was sought for removing the soil. A small gasoline powered pump, weighing nine pounds and capable of pumping 8 gallons of water per minute, was placed into operation. The siphon was placed in a small pool of the branch and the pump connected to 50 feet of garden hose which was used to "wash down" the site. This proved to be adequate, but slow, requiring three days of brush and broom assisted rock surface cleaning. The methodical pace used in exposing the glyph site features was expected to have permitted the recovery of identifiable cultural material. However, the total inventory of exposed cultural material consists of a single heat treated triangular projectile point, attributable to the Late Woodland Period (Futato, 1989).

With glyph exposure complete, the next step was gridding, mapping and photographing the features. A grid of 3 x 3 feet was established over the site and detailed photographs of each square made. Color photographs in 35mm slide and print format as well as 35mm stereo were taken. Many of the glyphs were so subtle or so faint that direct perpendicular photography did not provide the relief necessary to reveal the feature.

## A Woodland Petroglyph Site in Lamar County

Further, shadows cast by trees exacerbated the problem of shallow relief. A technique was discovered which greatly enhanced the photography of very faint glyphs. This was the simple expedient of photographing the features after dark, with electronic flash or flashes located up to twenty five feet from the camera. Using an automatic flash with sensor on camera and flash remotely located, the oblique angle which best highlighted the feature was determined by fixed auxiliary light, and the electronic flash placed in position. Then all fixed lighting was switched off and the flash photograph taken. This was repeated for all identifiable features.

During the summer months, latex molds were made of the features by using a liquid latex which was painted on in very thin layers and allowed to thoroughly dry between coats. As the latex buildup began, a filler material of coarse cloth was added to hasten the process. On particularly damp days, a small propane heater was used to assist in force drying the latex. In some instances, several days work were required for each glyph, particularly if rain, wind blown debris, or curious animals disturbed the mold, which could necessitate a restart of the whole process. However, once molds were complete and cured, excellent plaster replicas of the glyphs were produced.

The vicinity of the site was reconnoitered for evidence of other archaeological material. This reconnaissance was rather thorough for approximately one half mile radius on the same side of the river. Three small shelters having evidence of occupation plus a large level terrace site near the glyph site were located. One shelter contained a boulder possessing a conical mortar hole. Flint debitage and sand tempered pottery sherds were observed in the drip line of the other shelters. The terrace site contained extensive lithic debitage but no specifically identifiable cultural material.

## RESULTS AND DISCUSSION

The essence of the physical work is summarized in the various figures. In Figure 1 are illustrated the relative position of the principal features and their general orientation. The scale in Figure 1 is necessarily so small that detail is limited, but a coordinate system has been included to aid in locating specific features. The outstanding work of art at this site is located at coordinate E6 and illustrated in Figure 2. Pit-and-grooves, snakes and meanders may be seen in Figure 3 (C3). Diamonds, meanders and snakes are visible in Figure 4 (C2). The snake motif is especially evident in Figure 5 (C4) where several naturalistic and stylized forms are in evidence. Concentric circles and various meanders may also be seen in this figure.

A brief review of these dominant motifs will help place in perspective their possible significance at this location. Interpretation can, with certainty, only be based on historic accounts of particular motif use, but it can logically be extended further into the past since ceremonial practices evolved in the Southeast over long periods of time.

The "maze" or labyrinth is an enigmatic symbol in the Southeast. The example in Figure 2 has been identified here as a maze for lack of a



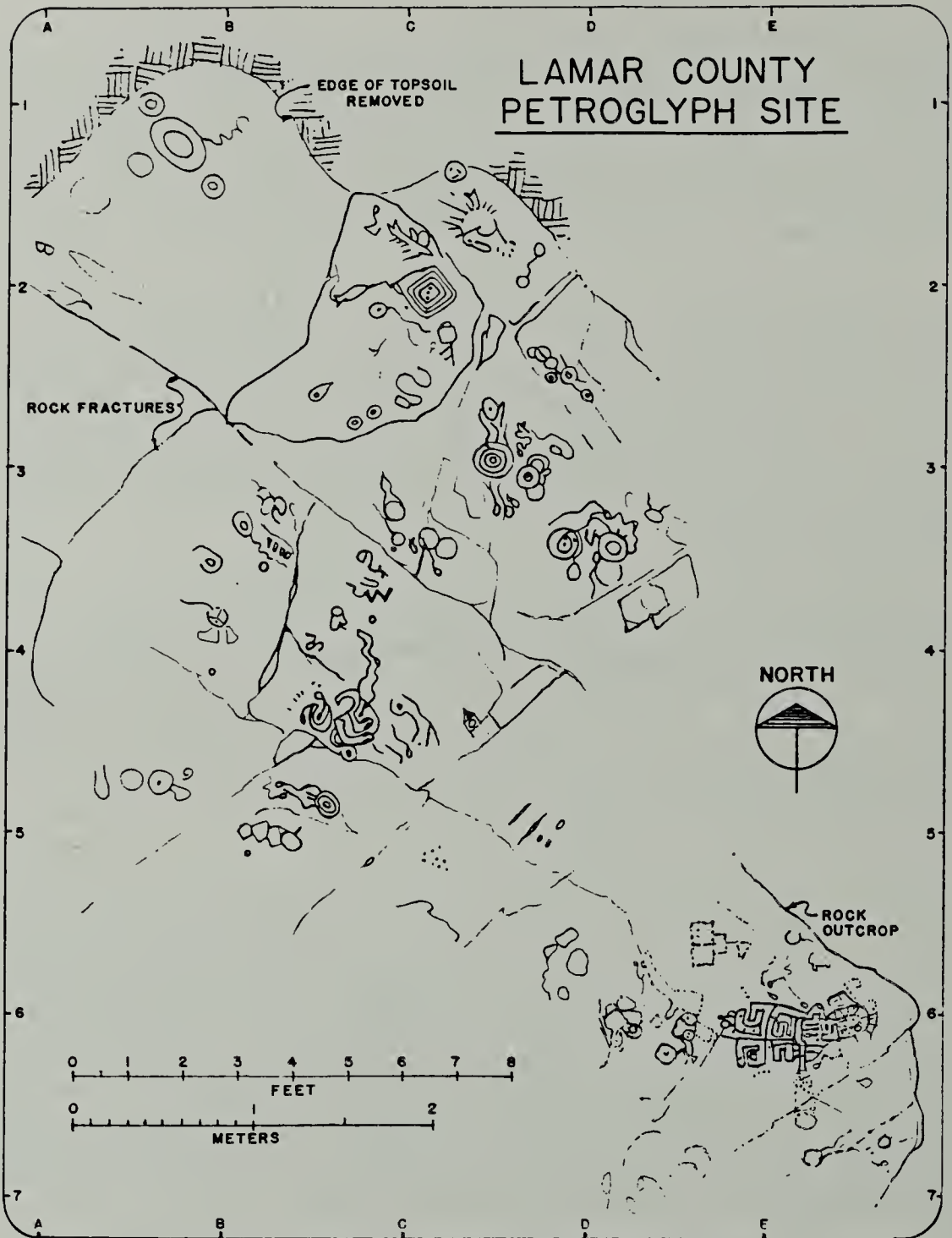


Figure 1. Plan view of glyph features.

more appropriate descriptive term and is the only one in Alabama known to the authors. This feature was created by pecking the design outline with a sharp tool followed by smoothing with a blunt abrading tool. There is considerable evidence of superpositioned pecking on the higher surfaces of the maze but no evidence that these pits and tool marks were intended to

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enhance or provide additional elements to the design. Whether the proximity of this glyph and several snake motifs has significance is not clear.



Figure 2. Maze feature - 1 meter in length. Several Snakes visible to the left of maze.

A petroglyph maze of similar size but different design is located in Grundy County, Tennessee (Henson, 1986), but cultural provenience is lacking in this instance. A number of tablets and plaques reminiscent of the Lamar County maze are associated with the Adena and Hopewell Cultures of the Woodland Period in the Ohio area (Brose, 1985). Most of these are rectangular, and some have been interpreted as stylized birds.

Pit-and-groove petroglyphs consist of small hemispherical pits, 1-2 centimeters deep and 3-6 centimeters in diameter, enclosed by pecked concentric circles typically .5 cm deep by 1 cm width. These occur worldwide and frequently at other sites in Northwest Alabama, with the style and rendering essentially the same in each instance. The use of this motif crosses cultural time periods, originating no later than the late Archaic (Henson, 1986) and appearing through the Mississippian Cultural Period.

The pit-and-groove style (Figure 3) has been identified as the Woodland Pit-and-Groove (Grant, 1983) with a distribution throughout the





Figure 3. Pit-and-Groove features. Snakes and meander lines are also present.

Tennessee Valley and contiguous areas. This style is believed to have begun in the Mississippi and Ohio Valleys around 1000 B.C. and spread throughout the Southeast as a manifestation of the Hopewellian Culture. Its probable significance is in relation to the sun or sun deity.

The diamond (Figure 4) and square, too, are ancient multicultural Southeastern Indian art forms, manifesting themselves in the ceremonial



Figure 4. Diamonds, Meanders and Snakes



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practices of historic Indians as "square grounds" for tribal dance activities. The diamond has been associated with snake forms in the Mississippian Period with the diamond forming the stylized head of the snake or the head and a large portion of the snake body. The diamond occurs prominently in Woodland pottery in the area of this site from 600-100 B.C. and is formed by cross-hatching on sand tempered Alexander pottery (Jenkins and Krause, 1986). Incised rectangular decorations are considered striking features of this pottery.

The snake (Figure 5) in Southeastern Mythology was a feared creature of the underworld, residing either underground or underwater, and was capable of bringing great misfortune to man. Various historic Indian tales relate in detail the dreaded "UKTENA" capabilities (Mooney, 1972).

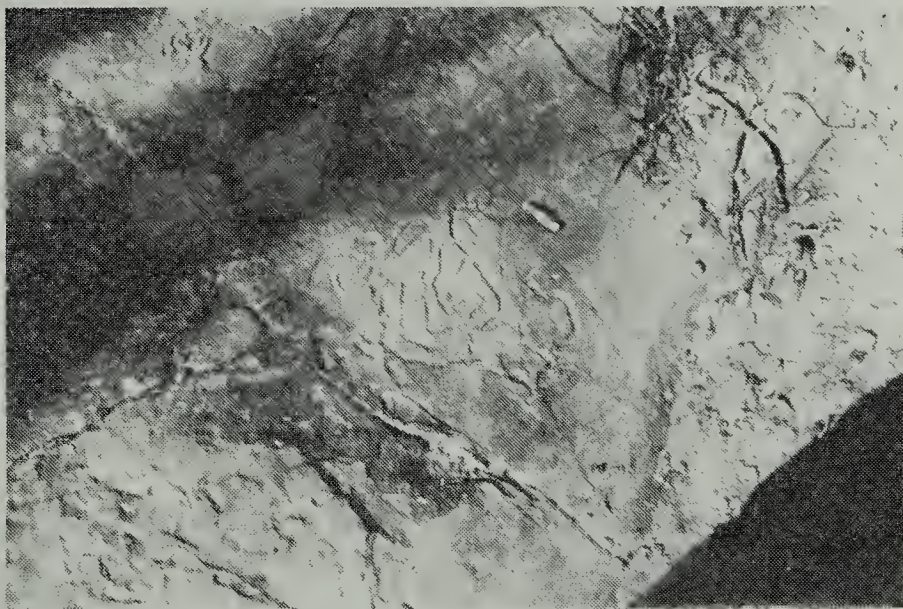


Figure 5. Snake Motifs. Concentric circles below and right of center. Meanders and miscellaneous pecked designs are also present.

Historic western Indians practice a noteworthy ceremony, aptly called the "snake dance," involving groups of dancers imitating snakelike movements while carrying snakes in their mouths (Hodge, 1910). The ceremony includes feasting and games, and is celebrated principally as a prayer for rain. Undoubtedly, the fascination and preoccupation with the snake and snake symbology so prevalent in the Mississippian Period evolved out of the Woodland Period which produced the most outstanding example, the Serpent Mound in Ohio, believed to be a religious effigy of the Hopewell people. This realistically shaped snake mound is approximately one-quarter mile long, 20 feet wide and 4 feet high.

The area which claims the Lamar County site has been subject to prior archaeological attention which helps illuminate the temporal position of this site. In 1965-66 the University of Alabama conducted a

survey which revealed 31 sites in the Buttahatchee Valley (DeJarnette et al., 1975a). These sites were identified by terrain locations: on terraces overlooking the flood plain, as low sites on frequently flooded meanders, and as shelter sites. One thoroughly investigated terrace site (1LR20) was determined by ceramic and lithic material analysis to have been occupied from the Early Archaic through the Woodland Period and to have had a short period of early Mississippian Period occupation. However, the most substantial occupation occurred during the Early Woodland Period, as revealed by Alexander ceramics and Flint Creek projectile points. Site 1LR34 (DeJarnette et al., 1975b) revealed a significant occupation during the Archaic Period with the final occupation occurring in the late Woodland Period. These two investigations also established the temporal and cultural position of a complex of crude core tools in the vicinity of the petroglyph site. It is to be noted that both the sites were represented by a dominant Woodland Period occupation which was for all practical purposes the terminal occupation period.

Another reported site in the same general area was determined to be an aboriginal sandstone quarry (Wright and Henson, 1968). Investigation of this site revealed conical holes in the sandstone bedrock, several stumps remaining from sandstone disc and/or vessel quarrying activities and a number of the ubiquitous pebble tools. Although no specific datable materials were recovered, the lithic material and quarry appear to represent the late Archaic Period, based on the technology transition from stone vessel manufacturing to pottery vessel manufacturing. These documented archaeological investigations suggest an Archaic and Woodland Period representation in the general area of this site, with Mississippian Period manifestations essentially nil.

The Tombigbee River drainage system's archaeological chronology, including the Buttahatchee River, has become much better understood in recent years as a result of the intense archaeological salvage work for the Tombigbee Waterway Project. This work has illuminated the subsistence and settlement patterns of the area (Jenkins, 1979) and places the preponderance of aboriginal occupation for the general area, encompassing this Lamar County site, in the woodland period.

Rock art, whether petroglyphs or in other forms, has been created for ceremonial/religious purposes, including magic, fertility, territorial markers, and records of important events (Barnes, 1982). Truly religious sites are typically private, occurring in small out of the way shelters accessible with difficulty or even in caves with limited accessibility. Since this site is open and easily accessible from all directions, it may be termed a public place for ceremony rather than a private place for religious purposes. The abstract nature of most features at this site suggest a ceremonial or magic purpose rather than marker, fertility or record purposes.

An interesting observation was made while working at this site. Present here and at most other petroglyph and pictograph sites are bedrock mortars, even in areas which appear to have been unsuitable for habitation, and thus without an obvious need of mortars for food preparation purposes. This is true both for late Mississippian petroglyphs which



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still have traces of paint in the glyphs and for glyphs which are stylistically older and exhibit no traces of paint. Thus, the possibility of an association of glyphs and mortars exists. Mortars at glyph sites may have been used to prepare pigments for the paint used on the glyphs. Painted petroglyphs in North Alabama are still visible in at least one Mississippian site (Henson and Martz, 1979).

### CONCLUSION

Placing rock art in its proper chronological framework by direct dating methods is presently not possible. Style and cultural associations, however tenuous, remain the most reliable dating method. Style represents a distinct and consistent set of characteristics for particular glyphs. Dimensions, manufacturing techniques, subject matter, and esthetics may serve as definitive cultural period indicators. Style at this site is consistent with numerous other sites in Alabama, Tennessee and Georgia which have by association been dated to the Late Archaic or Early Woodland Cultural Periods for the pit-and-groove glyphs. Archaeological excavations in the vicinity have determined the Woodland Cultural Period to be essentially the terminal habitation of the area. Finally, the classic motifs of the Mississippian Cultural Period are absent. Some of these absent features are the bi-lobbed arrow, mace, monolithic ax, cross and cross within a circle. The principal feature, the maze, and other known maze-like features are not known to occur at any site later than Woodland. It is therefore concluded that the Lamar County petroglyph site is a Woodland ceremonial site, 100 B.C. to A.D. 900.

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### LITERATURE CITED

- Barnes, F. A. 1982. *Prehistoric Rock Art*. Wasatch Publishers, Inc.  
Salt Lake City, Utah.
- Brose, David S., James A. Brown and David W. Penney 1985. "The Woodland Period" in *The Ancient Art of the American Woodland Indians*. Harry N. Abrams, Inc. New York.
- Carlston, Charles W. 1944. Ground-Water Resources of the Cretaceous Area of Alabama. *Geological Survey of Alabama, Special Report #18*. University, Alabama.
- DeJarnette, D. L., John A. Walthall and Steve B. Wimberly 1975a. Archaeological Investigations in the Buttahatchee River Valley, Lamar County, Alabama. *Journal of Alabama Archaeology*, Volume 21, No. 1, June 1975.



- DeJarnette, D. L., John A. Walthall and Steve B. Wimberly 1975b. Archaeological Investigations in the Buttahatchee River Valley, Lamar County, Alabama. *Journal of Alabama Archaeology*, Volume 21, No. 2, December 1975.
- Futato, Eugene M. 1989. *An Archaeological Overview of the Tombigbee River Basin, Alabama and Mississippi*. University of Alabama State Museum of Natural History, Division of Archaeology, Report of Investigations 59.
- Grant, Campbell 1983. *The Rock Art of the North American Indians*, Cambridge University Press, Cambridge.
- Henson, B. Bart 1976. A Southeastern Ceremonial Complex Petroglyph Site. *Journal of Alabama Archaeology* Volume 22, No. 2, December 1976.
- Henson, Bart and John Martz 1979. *Alabama's Aboriginal Rock Art*, Alabama Historical Commission, Montgomery, Alabama.
- Henson, B. Bart 1986. Art in Mud and Stone: Mud Glyphs and Petroglyphs in the Southeast in *The Native American Art of Mud Glyph Cave*, edited by Charles H. Faulkner, University of Tennessee Press, Knoxville, Tennessee.
- Hodge, Frederick W. 1910. *Handbook of American Indians North of Mexico*, Part 2 of American Ethnology Bulletin 30, Pageant Book, Inc. Reprint 1959. New York.
- Jenkins, Ned J. 1979. Miller Hopewell of the Tombigbee Drainage in *Hopewell Archaeology*, edited by David S. Brose and N'omi Gerber. Kent State University Press.
- Jenkins, Ned J. and Richard A. Krause 1986. *The Tombigbee Watershed in Southeastern Prehistory*. University of Alabama Press, University, Alabama.
- Mooney, James 1900. Myths of the Cherokee in the *Nineteenth Annual Report of the Bureau of American Ethnology*.
- Peirce, Laurence B. and James W. Geurin 1959. Surface Water Resources and Hydrology of West-Central Alabama, *Geological Survey of Alabama, Special Report 24*, University, Alabama.
- Semmes, Douglas R. 1929. *Oil and Gas in Alabama, Special Report 15*, Geological Survey of Alabama, University, Alabama. July 1929.
- Soil Survey of Marion County Alabama 1975. USDA General Soil Map.
- Wright, A. J. and B. Bart Henson 1968. An Aboriginal Sandstone Quarry in Lamar County, Alabama. *Journal of Alabama Archaeology*, Volume 14, No. 2. December 1968.

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**COVER PHOTOGRAPHS:** Four views of pitcher plant habitats in the southeastern United States (see article this issue). Pitcher plant habitats are known for their aesthetic appeal as well as their biological uniqueness. **Upper left** - An April display of the flower-like pitchers and red flowers of the white-topped pitcher plant (*Sarracenia leucophylla*) in a seepage bog in Baldwin County, Alabama. This site, one of the most diverse known, has been destroyed by grazing since this picture was taken. **Upper right** - Yellow pitcher plants (*Sarracenia flava*) and the narrow glistening leaves of the thread-leaved sundew (*Drosera filiformis*), another carnivorous plant, growing together in a sloping seepage bog in Covington County, Alabama. **Lower left** - The reddish leaves of the yellow pitcher plant (*Sarracenia flava*) in a seepage bog in the Apalachicola National Forest in Liberty County, Florida. In some populations, pitchers of the yellow pitcher plant become heavily tinted with red anthocyanin pigments, especially late in the season. **Lower right** - Winged pitcher plants (*Sarracenia alata*) growing with white-flowered big-leaved bog gentians in a muck bog in Harrison County, Mississippi.

George W. Folkerts is in the Department of Zoology and Wildlife Science at Auburn University.

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Lawrence C. Wit, College of Science and Mathematics, Auburn University, Auburn, AL 36849

William Osterhoff, Department of Criminal Justice, Auburn University at Montgomery, AL 36193

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## A PRELIMINARY CLASSIFICATION OF PITCHER PLANT HABITATS<sup>1</sup> IN THE SOUTHEASTERN UNITED STATES

George W. Folkerts  
*Department of Zoology and Wildlife Science*  
*Auburn University*  
*Auburn University, AL 36849*

### ABSTRACT

Habitats harboring pitcher plants of the genus *Sarracenia* occur throughout much of the Coastal Plain of the southeastern United States. These areas are typified by frequent fires, acid soils, soil saturation during at least a portion of the year, and a distinctive biota. Much of the acreage once occupied has been destroyed or drastically modified. Pitcher plant habitats may be classified on the basis of their topographic, hydrologic, and edaphic characteristics. The eleven habitat types described included stream and river terrace habitats, depressed drainageways, sinkhole pond edges, Carolina bay habitats, sphagnum mat bogs, seepage bogs, springhead seepages, muck bogs, savannas, swales, and anthropogenic habitats. Seepage bogs and savannas make up the bulk of the acreage still remaining.

### INTRODUCTION

Habitats in which pitcher plants of the genus *Sarracenia* were conspicuous were once quite common in the southeastern United States (Folkerts 1982). Although greatly diminished, a diversity of sites still remains from which information about physical conditions and biotic composition can be obtained. Although the habitats differ in topography, hydrology, and species composition, they have in common a high fire frequency, low soil pH, and soil saturation for at least a portion of the year. In these sites, *Sarracenia* species are often associated with other elements of a distinctive vascular flora, giving the impression that a discrete community exists, although the habitat requirements and extent of co-occurrence of the component species vary considerably. Abrupt lateral changes in floristic composition may result from the juxtaposition of drier areas with areas where high soil moisture results from seepage. This phenomenon often serves to heighten the apparent distinctiveness of the community. Although debate continues concerning the usefulness and validity of the community concept, these assemblages of species are as well-defined in the southeastern United States as most other purported community types.

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Temporal dynamism is characteristic of nearly all plant communities in the southeastern U.S. Over periods of time, pitcher plant habitats are continually expanding, contracting, disappearing, re-appearing, and changing position relative to adjacent vegetation types. These changes are mediated by fire, amount of shade, invasion by other species, and changes in soil moisture content. Fire frequency and timing seem to be the most important factor. Fire-mediated alternation of southeastern wetland vegetation types was noted by Frost et al. (1986). However, it is probably inappropriate to consider these habitats are merely ecotonal, a viewpoint implied by Roberts and Oosting (1958), and Means and Moler (1978). These sites harbor a number of characteristic or unique species rather than merely consisting of an admixture of species from more discrete adjacent communities. Roberts and Oosting (1958) (who used the terms "semi-pocosin or semi-savannah") may have viewed these communities as ecotonal because of the relatively abrupt changes in elevation that often occur between dry pine savannas and pocosins at the sites in North Carolina where they worked. Under such conditions, pitcher plant communities may occupy narrow ecotone-line zones. Before disturbance and fire restriction, and presumably in pre-Columbian times, pitcher plant habitats occupied extensive areas (Brickell 1737, Bartram 1791, Williams 1827). Walker and Peet (1983) believed that the presence of many unique species was evidence for the "antiquity of the assemblage." Fire restriction has reduced some pitcher plant habitats to small patches or narrow linear areas that may be perceived as ecotones. However, such patches probably always occurred as a result of the tremendous variability in the characteristics of fires and differences in the extent, frequency and timing of natural burns.

The conspicuous flora of these communities consists almost entirely of heliophytic perennial herbaceous vascular geophytes. Although a given stand seldom contains more than 100 species, the abstract community includes approximately 260 characteristic vascular plant species, more if certain species occurring only in Texas bogs are included. Under what may be assumed to be primeval pyric conditions (if such an assumption has a valid basis), these herbaceous communities probably comprised a self-perpetuating vegetation type on many sites. The herbaceous perennials of these habitats are not characteristic of wooded sites, nor are more than a handful of woody species typical components of the pitcher plant community. Sites in which woody species are abundant are usually those in which fire has occurred at relatively infrequent intervals. Many of the characteristic plants have the ability to survive for long periods as the habitat is invaded by woody types during a long fire-free period. This seems to have given some workers the erroneous impression that these communities are anthropogenic artifacts. Penfound's (1952) contention that these communities develop mainly as a result of removal of woody vegetation probably resulted from the re-appearance of dormant plants and recolonization by species that did not survive a protracted period without fire. When dense woody vegetation is removed, whether by an intense fire, windthrow, or harvest, dormant plants again become active and produce above-ground portions. Conde et al. (1979)



## Classification of Pitcher Plant Habitats

noted the apparent reappearance of bog species on logged sites in Franklin Co., Florida. Coultas et al. (1979) observed a similar response when a path was cut through a titi swamp in Leon Co., Florida. In Liberty Co., Florida, after a site where no pitcher plants were previously visible was logged, I found large *Sarracenia flava* rhizomes producing leaves and flowers. The rhizomes at this site could have been dormant for as long as two decades. A similar phenomenon occurred in Baldwin Co., Alabama, after clearing for power line construction. At this site, no active *Sarracenia* had been seen for 16 years. However, because under conditions of extreme shade, the rhizomes of some *Sarracenia* species produce only phyllodia, intensive scrutiny may be necessary to reveal their presence. In the aforementioned cases, timber removal functioned in a manner analogous to that of fire. Fire is known to stimulate growth in some *Sarracenia* species (McDaniel 1971, Barker 1984, Barker and Williamson 1988). The existence of this community clearly depends on a site being maintained in a certain successional stage, but this fact carries with it no implication that pitcher plant habitats are artifacts.

Understanding of the ecology of the flora is further complicated because many of the species are occasionally found in sites where they seldom reproduce, such as cypress and tupelo swamps, bottomland hardwood forests, sand and gravel bars along streams, among dense pocosin and shrub bog vegetation, and in freshwater marshes. These sites are usually dispersal sinks (*sensu* Pulliam 1988) and cannot be considered areas in which species typical of pitcher plant communities maintain themselves. In other cases, fire restriction has allowed succession to occur and the pitcher plant community is present as a few surviving remnants. Variation in microtopography and concomitant soil moisture levels often allow species which are not typical to grow among the more characteristic flora. The appearance of these species in lists developed during floristic studies adds further to the confusion about the biology of these habitats. Finally, the pitcher plants themselves, and probably many of the other species, vary geographically in their tolerances to physical and biological conditions. A number exhibit what may be an array of different ecotypes that differ in phenotype and in their apparent microhabitat preferences.

Pitcher plant habitats may be associated with a number of soil types. Only a brief summary of soil characteristics can be presented here. Most soils fall into the great groups called Paleaquults, Ochraqults, and Psammaquents. Difficulty is encountered in determining if there is consistency as to which soil series harbor these communities. Soils with seemingly identical characteristics are mapped differently in different county soil surveys. Additionally, the modern soil surveys, completed since 1975, use a different scheme of classification and series terminology than older surveys. Hence, no soil series names are listed here. However, the soil series tend to differ among the different habitat types proposed in the following classification. Texturally, surface soils are most frequently sands, loamy sands, or sandy loams. Most consist of more than 60 percent sand. Some sites at points along the Gulf Coast are high in clay. Clay is often abundant at lower levels. Fine clays and silts



were noted to characterize some sites (Wolfe et al. 1988). Scattered sites occur, especially in south-central Georgia and central Alabama, where the soil is gravelly (Harper 1922).

The soil reaction in southeastern pitcher plant habitats is invariably acidic. Electrometric field and laboratory tests on soils from 42 sites extending from North Carolina to Louisiana, conducted during 1986-1989, revealed pH values ranging from 3.5 to 5.3. Organic matter content is typically low, ranging from 0.8 to 6.7 percent at sites tested by carbon analysis during 1988-1989. Exceptions are muck bogs and sphagnum mat bogs where the substrate is largely composed of organic material. Nutrient levels have traditionally been considered to be low, but literature reports do not clearly indicate that such is the case at all sites (Eleuterius and Jones 1969, Nixon and Ward 1986). Little information is available on micronutrients. Anthropogenic alterations of nutrient levels have complicated the interpretation of nutrient data. Further information on soil characteristics at various sites may be obtained from Plummer (1963) and others.

Most pitcher plant habitats discussed here cannot be considered peatlands. At least they are not usually peatlands of the classical ombrotrophic type. Although deposits of peat exist in the southeastern United States, it is unlikely that a significant portion of these have resulted from the accumulation of organic material in pitcher plant habitats. Under natural conditions, frequent fires remove litter that might otherwise accumulate and become peat. To many familiar with the general term "bog," the word calls to mind the sphagnum, sedge-mat, quaking, or peat bogs of the type that occur throughout the northern hemisphere in a circumboreal pattern in association with glacial topography and boreal forest vegetation (see Dansereau and Segadis-Vianna 1952, Gorham 1957, Heinselman 1963, Osvald 1970, Larsen 1982, Crum 1988, and others). Habitats of this type are absent from the Coastal Plain of the southeastern United States. Where analogous communities occur, they are different in species composition from boreal types (see discussion of sphagnum mat bogs). Frost et al. (1986) have censured those who have applied the term "bog" to southeastern pitcher plant habitats, advancing the novel idea that locals "know better." The term "bog" is, in fact, used by locals in the mid-South, but such usage is not relevant to the use of terminology among biologists. Moreover, as Crum (1988, p. 1) pointed out, locals in the northern U.S. refer to bogs as swamps. Were we to adopt the local vernaculars for these habitats we would have to deal with "crawfish flat," "lily flat," "flycatcher field," "saug," and a host of other nebulous terms of local and regional origin. Frost et al. implied that the term "savanna" should be used for all of these habitats. In my opinion, the use of "bog" by astute students of southeastern environments such as Kral (1955), Wells (1967), and Wharton (1977), justifies maintenance of the term. "Savanna" may also be appropriately used but not because it is without ambiguity since it originally applied to tropical sites and was defined early as "xerophilous" (Schimper 1903, see also Dyksterhuis 1957).

## Classification of Pitcher Plant Habitats

Folkerts (1982) estimated that only three percent of the pre-Columbian acreage of pitcher plant habitats along the Gulf Coast had not been destroyed or severely altered. Fire restriction, alteration of fire periodicity and seasonality, drainage, grazing, pond construction, and urbanization have been the major causes. A major reason for drainage has been the attempt to convert large acreages to pine monoculture. Drainage of savannas and bogs is an accepted practice in this endeavor (Allen and Campbell 1988). Since 1982, the rate of destruction has increased significantly. Damage resulting from off-road vehicle traffic and increased herbicide use in forests and along highways has compounded previously existing problems. Currently, removal of entire plants and the harvest of pitchers for the horticultural trade pose additional threats.

Gibson (1983) noted that no classification scheme had been devised for these habitats. A terminology and classification for these systems seems desirable. Not only is it needed to enable scientists to communicate, but it is vital for effective conservation efforts. A tentative scheme of classification is proposed here. It should not be assumed that all of these habitats are of equal significance in considerations involving conservation of pitcher plant communities. It is likely that some, especially certain of the stream and river terrace sites, are dispersal sinks, and are therefore relatively unimportant in the long-term survival of most of the species (Pulliam 1988). This classification scheme has been devised for sites on the Coastal Plain only. With some modification it may also be applicable to habitats above the Fall Line that harbor *Sarracenia rubra* subsp. *jonesi* (Wherry 1929), or *S. oreophila* (Dennis 1980, Schnell 1980).

The system proposed below is based on information and impressions garnered during the last 18 years from visits to approximately 450 sites from southeastern Virginia south to south-central Florida and west to Robertson Co., Texas. The system is based mainly on topography, hydrology, and soil conditions, since these are major determinants of vegetation type. Hydrology is emphasized. Crum (1988) contended that the best classification schemes for wetland habitats are based on water source and movement. This classification scheme is proposed to draw attention to the habitat diversity even though a given site may not be easily placed in a category and almost all possible combinations of intermediacy can be found. A variety of conditions may combine to produce sites in which pitcher plant communities are present. Those who wish for discreteness in schemes of classification fail to understand nature. Novitzki (1978) devised a hydrologic classification for wetland plant communities that, with some modification, is applicable to pitcher plant habitats. I refer to his scheme when appropriate in the following discussion.

A CLASSIFICATION OF PITCHER PLANT HABITATS  
IN THE SOUTHEASTERN UNITED STATES

- I. ASSOCIATED WITH SURFACE WATERS
  - A. Associated With Lotic Waters
    - 1. Stream and River Terrace Habitats
    - 2. Depressed Drainage ways
  - B. Associated With Lentic Waters
    - 1. Sinkhole Pond Edges
    - 2. Carolina Bay Habitats
    - 3. Sphagnous Mat Bogs
- II. NOT ASSOCIATED WITH SURFACE WATERS
  - A. Moisture Input From Groundwater
    - 1. Seepage Bogs
    - 2. Springhead Seepages
    - 3. Muck Bogs
  - B. Moisture Input From Precipitation
    - 1. Savannas
    - 2. Swales
- III. ANTHROPOGENIC HABITATS

**Stream and River Terrace Habitats (Fig. 1)**

Variations in water levels in streams and rivers conjoined with runoff frequently cause soil saturation in areas adjoining the watercourse. Fire encroachment from the surrounding uplands maintains openness in many of these





Fig. 1. A stream terrace pitcher plant habitat in Santa Rosa County, Florida. The area of shrubs on the left marks the border of the stream which has been dammed by beavers. The bog forms an undulating border along the stream. To the right the land rises and the vegetation is a type typical of dry pine savannas. *Sarracenia leucophylla*, *S. psittacina*, and *S. purpurea* are common, but *S. flava* also occurs.

sites. Usually they occur above the first natural levee, if one exists. The pitcher plant community is separated from the low-water channel by areas supporting other vegetation types. Stream and river terrace habitats fall into the category called surface water slope wetlands by Novitzki (1978). These sites receive water as watercourse levels rise but are seldom flooded for more than a few weeks. Soils may be saturated for longer periods because of proximity to surface water. Where the habitats occur adjacent to blackwater streams, groundwater seepage may be an additional factor in soil moisture content (Winner and Simmons 1977). Most of the



acreage of habitats of this type occurs along the Gulf Coast in the Florida Panhandle, but scattered sites may be found elsewhere. Stream and river terrace habitats were probably never common because the heavy alluvial soils that occur adjacent to many watercourses do not support this community. Many of these sites may be dispersal sinks for source populations that exist upstream.

### **Depressed Drainage ways**

Depressed drainageways are sites where erosion has produced a concave elongated trough through which water flows only after rains. Seepage typically does not contribute to the soil moisture in the drainageway. There is usually no well-defined stream channel. Soil moisture is derived from the flow of water through the rough after rains. Thus, only drainageways with a surrounding topography that frequently directs water through the site are able to support the pitcher plant community. Pitcher plants and associated flora typically occupy a border area between lower portions of the drainageway and areas of higher elevation where the soil is too dry. The lowest portions of the drainageway usually harbor woody vegetation, and often resemble shrub bogs or pocosins in their species composition. At times, slash pines or pond pines occupy the lower area.

### **Sinkhole-Edge Habitats**

From southern Georgia through northern Florida and westward along the Gulf to south-central Alabama, karsting phenomena have resulted in the presence of many sinkholes or limesinks. The water level in these depressions may fluctuate considerably as a result of precipitation, evaporation, and local runoff. The water in the depression may be perched above the water table on an impermeable floor. Less frequently a connection with the underground aquifer exists. At the edges of some sinkholes, soil and moisture conditions combine to create sites suitable for pitcher plant community development. Often the community is patchily intermingled with other community types. Sinkhole-edge habitats fall into Novitzki's category of surface water depression wetlands, sites where precipitation and overland flow collect in a depression. What small amounts of habitat of this type existed have been largely eliminated by fire suppression and disturbance

### **Carolina Bay Habitats**

From southern Georgia to the southeastern corner of Virginia, there occur elliptical depressions of uncertain origin and varying sizes. These features, commonly called Carolina bays, have water levels depending on precipitation and seepage and are usually unassociated with surface drainages. Sharitz and Gibbons (1982) have described the hydrological features of these sites. The pitcher plant habitats may be present at the edges of these habitats when the bays contain lakes. In this case, the



## Classification of Pitcher Plant Habitats

habitats are physically similar to those at the edges of sinkholes. In both sinkhole and bay-edge habitats, the community tends to be a relatively narrow strip. The upper level of this area is defined by the upper reaches of soil saturation resulting from rises and falls in the body of water. The lower level tends to approximate the lowest reach of frequent fires. In other cases, the bay may be filled with peat and support pocosin-like vegetation. Occasionally a marsh-like community develops. The pitcher plant community is often patchily distributed or restricted to natural or artificial openings (Porcher 1966). Fire suppression has eliminated much of the acreage of pitcher plant habitat associated with Carolina bays.

### Sphagnous Mat Bogs (Fig. 2)

Sphagnous mat bogs are typical pitcher plant habitats, consisting of a floating or attached mat of vegetation that includes a dense growth of *Sphagnum*. The flora



Fig. 2. A sphagnous mat pitcher plant habitat in the Okefenokee Swamp in Charlton County, Georgia. A plant of *Sarracenia minor* is barely visible near the lower left of center. Scattered *S. psittacina* are also present.



may become relatively speciose, but does not show the species richness of seepage, savanna or muck habitats. The only pitcher plant conspicuous in sphagnum mat bogs is the so-called "giant" form of *Sarracenia minor*, apparently a unique ecotype restricted to these sites. *Sarracenia psittacina* occasionally occurs. Although floating mats of vegetation occur on many bodies of water in the southeastern United States (e.g., Orange Lake in Florida and Blue Girth Swamp in Alabama), albeit not usually incorporating *Sphagnum*, the only floating mats that support a community similar to that in more typical pitcher plant habitats are in the Okefenokee Swamp in southeastern Georgia and northeastern Florida. Okefenokee sphagnum mats also harbor abundant species such as *Dulichium arundinaceum* which are not common in other types of pitcher plant habitats. A few taxa occur, such as *Eriophorum virginicum*, which are characteristic of boreal bogs. The terminology applied to communities in the Okefenokee swamp has been complicated by an attempt to adapt local colloquial terms to scientific use. Little consistency has resulted. Wright and Wright (1932) refer to these habitats as "marginal bogs." Wharton (1977) included them in a category termed "sphagnum bog." Okefenokee natives and many scientific works also often call them "prairies," although this term may also refer to open water areas with emergent aquatic macrophytes. McCaffrey and Hamilton (1984) used the term "herbaceous prairie." These habitats are often subdivided by local people into "hard (in contact with the bottom) prairies" and "soft (floating) prairies" (pers. comm., C. Trowell). Floating mats have also been called "batteries" (Haddock and Todd 1982), another term of local origin.

#### Seepage Bogs (Figs. 3,4)

Seepage bogs occur at sites where water moves downslope through a layer of sandy soil. They are groundwater slope wetlands (Novitzki 1978). Their occurrence is often dependent on the undulating nature of former dune systems that resulted in the sandy soils on which they now occur. Discharge occurs where porous sands are capped by other strata or at a level reflecting the downslope flow of water in a sandhill. The upper border of the seepage zone is often marked by a small declivity and is typically characterized by a rather abrupt change in the flora. The downslope contour is usually concave, sometimes conspicuously so, but may be relatively flat as in the case of the seepage bogs often referred to as "seepage savannahs" (Wolfe et al. 1988). Water often drains into a small stream at the base. Extensive areas may contain a dendritic drainage pattern of small streams or rivulets, most less than 0.5m in width. Downward percolation of the water is inhibited because the entire layer or sand is saturated or because restrictive layers of impermeable clay or other materials lie beneath the surface. The zone of saturation is therefore an unconfined aquifer perched above the true phreatic level. Saturation of the soil in seepage bogs sometimes seems mystifying since superficial examination often gives the impression that there is an insufficient catchment area at higher elevations to provide the amount of water obviously present in the soil, even though downslope water movement is slow. Capillary action may play a part in bringing deep water to the surface at some





Fig. 3. A steeply sloping seepage bog in George County, Mississippi. The conspicuous pitcher plant is *Sarracenia alata*, but *S. psittacina* is also common.

sites. At others, it seems that artesian pressure, perhaps from an area of escape of a confined aquifer, forces water upward to the zone of seepage, but hydrological data on this phenomenon are sparse. Clewell (1981) reported that artesian pressure from an aquifer flowing out from under the Jackson Bluff Formation resulted in surface soil saturation at a site in Leon Co., Florida.

A variety of names has been applied to seepage bogs. The term "hillside bog," which was used at least as early as Kral (1955), is often used. "Seepage savanna," another term which is not uncommon, is usually applied to flatter sites (Wolfe et al. 1988). The term "open bog" has been used to distinguish seepage bogs from shrub bogs which are "closed" by woody vegetation (Hubbell et al. 1956). Some of the sites which Wells and Shunk (1928) called "xeric grass-sedge bog communities" are seepage





Fig. 4. A gradually sloping seepage bog in Liberty County, Florida. *Sarracenia flava* is the conspicuous pitcher plant, but *S. psittacina* and *S. purpurea* also occur.

bogs, but others are savannas. Clewell (1971) called seepage bogs in Apalachicola National Forest "*Pleea* phase savannahs," also distinguishing less typical types of the "hat rack phase," and "pine-titi phase." He also mentioned the unusual "*Verbesina*-phase savannahs" with heavier soils. Later he (Clewell 1981) referred to such sites in the Florida Panhandle as "grass-sedge seepage bogs." Nixon and Ward (1986) divided the eastern Texas seepage bogs they studied into basin bogs and slope bogs. They described basin bogs as "spatulate shaped simibasins with seepages and springs occurring on three sides." Slope bogs were characterized as "single slopes with springs and seepages," and perhaps are more appropriately placed in the springhead seepage category in the present classification.

Ajilvsgi (1979) used the term "acid bogs" for certain pitcher plant habitats in the Big Thicket region of eastern Texas, grouping them as types of Bay-Gallberry



Holly Bogs. She noted that small areas of boggy habitat on slopes have been referred to as "hanging bogs." From visits to sites in the Big Thicket area, I believe that these properly fall into the category of seepage bogs. I have also visited the Texas sites mentioned by Telfair (1988). They have characteristics of seepage bogs, but some are more linear and resemble springhead seepage sites. The sites Wharton (1977) and Wolfe et al. (1988) called "herb bogs" belong in this category. Gibson (1983) used the term "hillside seepage bog." Norquist (1985) called these sites "bogs," and considered them distinct from "savannas." She also noted a tendency for this habitat to be more abundant farther inland, whereas savannas are more typical of areas closer to the coast. This difference in proximity to the coast tends to occur through the Gulf Coast. However, on the Atlantic Coastal Plain, where seepage bogs are less common, the two habitat types tend to be more intermingled, with savannas occurring farther inland than along the Gulf Coast. The presence of seepage bogs implies a history of baseleveling in which sandy strata, usually of Miocene age, have been eroded, resulting in an undulating topography.

Seepage bogs have a long hydroperiod (period of soil saturation in this case), longer than any other pitcher plant habitat except springhead seepages, muck bogs, and sphagnum mat bogs. In many, the soil at the surface is saturated for the entire year. The floristic species richness of these sites is greater than in any other pitcher plant habitat type. Wells (1967) noted that "it is the wettest bog which gives us the most flowers." Clewell (1981) indicated that these habitats probably contained more species per unit area than any other community in the Florida panhandle. One site in Baldwin County, Alabama, harbored over 130 herbaceous species before its destruction by grazing. *Sphagnum* is usually present in seepage bogs in which the soil is mainly sand, but may be absent in sites where greater amounts of clay are present. However, *Sphagnum* is seldom a dominant because its growth is continually set back by fires. Some seepage bogs have scattered trees. In the wettest sites, both swamp tupelo (*Nyssa biflora*) and pond cypress (*Taxodium ascendens*) may be present. Seepage bogs are most common from Texas to southwestern Georgia. They are especially abundant in southern Mississippi, southern Alabama, and the western Florida panhandle. Many of the bogs in eastern Texas and western Louisiana are also of this type (Allen, et al. 1988, B. MacRoberts and M. MacRoberts 1988, 1990, M. MacRoberts and B. MacRoberts 1990). Burrowing crayfish of the genus *Fallicambarus* are conspicuous components of these habitats and are significant in their nutrient dynamics and in microsuccessional phenomena (unpublished information).

### Springhead Seepages

Springhead seepage habitats are, in a sense, narrow, linear seepage bogs, perpendicular to the slope. These habitats are found where soil saturation results from seepages or tiny springs that originate at an upslope point. Springhead seepages are similar to seepage bogs hydrologically, but the discharge area is localized rather than diffuse. Tiny rills may flow downslope through the center of springhead seepage



habitats. In unshaded springhead seepages, the flora may be quite diverse. However, because the habitats are often linear, arborescent vegetation from areas outside the seepage zone often shades the seepage for a portion of the day. Under this condition, the flora is usually depauperate and *Sarracenia purpurea* may be the only pitcher plant present. *Sphagnum* species are often conspicuous in springhead seepage habitats.

### Muck Bogs (Fig. 5)

In muck bogs, the underlying soil consists of a thick organic slurry, kept saturated by seepage from surrounding areas of greater elevation. The soil is completely saturated throughout the year. The surface of muck bogs tends to be relatively level rather than concave or sloping as is typically the case in seepage bogs.



Fig. 5. A large muck bog in Harrison County, Mississippi. *Sarracenia alata* is in flower. *Sarracenia psittacina* is also abundant to this site.



## Classification of Pitcher Plant Habitats

The surface consists of the mass of intertwined roots, rhizomes, and other surface and subsurface portions of the plants present. Movement of water through muck bogs is very slow, but drainage usually occurs by way of small streams. Muck bogs may lack arborescent vegetation even when fire has been absent for a number of years. However, they become obscured by succession when fire has been absent for several decades. *Sphagnum* is always present, and often forms mounds, especially in the absence of fire. Muck bogs are usually floristically rich, but not as rich as seepage bogs. Although generally level, undulating microtopography is often present as a result of differential growth of *Sphagnum* masses in some areas. In this respect, muck bogs resemble ombrotrophic bogs more than do any other southeastern pitcher plant habitats. Their origin is problematical, but they seem to have formed when a small drainage was partially dammed by natural processes and organic material gradually built up in the area behind the obstruction. The organic material may be derived from the gradual downslope accumulation of the products of decay in adjacent seepage bogs. The peaty material itself may have formed the original obstruction to water flow. The accumulation of the organic material obscures the drainage beneath it. The slurry-like characteristic results from very slow drainage of the water. Muck bogs occur mainly in southern Mississippi and adjacent Alabama. Muck bogs have been called quaking bogs by some authors (Eleutarius 1968) but are not similar to the quaking bogs of the northern portions of the continent. They do not seem to be the result of mat growth from peripheral areas, nor are most present at sites that were formerly lakes or ponds. The small areas of open water present in some are the result of disturbance.

### Savannas (Figs. 6,7)

Pitcher plant savannas (often spelled "savannahs") are characterized by little relief or slope. The term savanna has long been applied to such sites in the southeastern United States by many workers, but Dyksterhuis (1957) has pointed out some usage problems with the general term. A variety of terms have been used to refer to pitcher plant savannas. Some have called them flatwoods, but as traditionally viewed, flatwoods are drier sites, often harbor saw palmetto (*Serenoa repens*), within its range, and/or a variety of woody species, and are not dominated by grasses and sedges. Sandifer et al. (1980) felt that, in South Carolina, savannas most commonly occurred in poorly drained interstream flats among pine flatwoods. Hubbell et al. (1956) used the term "pine flatwoods" of the pitcher plant type." Harper (1906) called pitcher plant savannas in southeastern Georgia "moist pine barrens." His terminology was followed by Pullen and Plummer (1964). A number of the Georgia sites which Harper studied are seepage bogs. Some of the sites which Wells and Shunk (1928) called "xeric grass-sedge bog communities" are savannas. Later, Wells and Whitford (1976) mentioned both "grass-sedge bogs" and "savannahs." Clewell (1971) termed savannas with heavy loamy soils in Apalachicola National Forest "Verbesina Phase Savannahs." He later (Clewell 1981) used the term "boggy flatwoods" to refer to a site in Franklin Co., Florida.





Fig. 6. A pitcher plant savanna in Orangeburg County, South Carolina. *Sarracenia flava* is the most evident pitcher plant, but clumps of *S. minor* may also be seen. Both *Pinus serotina* and *Pinus palustris* are present.

Wharton (1977) termed some southern Georgia sites "cypress savannahs." Ajilvsgi (1979) referred to eastern Texas savannas supporting carnivorous plants as "Longleaf-Black Gum Savannahs." Streng and Harcombe (1982) used the term "grass-sedge meadow" for east Texas sites. The term "pine savannah" is often used (Kologiski 1977, Gaddy 1982, Jones and Gresham 1985), but that term, as used by many workers, includes dry pine savannas which do not support the community discussed here. Barry (1980) described types called "pine-toothache grass savannah," and "pond cypress savannah" for South Carolina sites harboring carnivorous plant assemblages. Gibson (1983) used the term "flat savannah bogs." Walker and Peet (1983) termed the North Carolina areas they studied "pine-wiregrass savannas." They divided them into dry, mesic, and wet types. Only the mesic and wet types contained pitcher plants.





Fig. 7. A pitcher plant savanna in Jackson County, Mississippi. *Sarracenia alata* is the abundant species in flower, but *S. leucophylla* flowers are also visible. *Sarracenia purpurea* and *S. psittacina* also occur. The pines are *Pinus palustris* and *P. elliotii*

Christensen (1979, 1988) summarized some of the literature on savannas in the southeastern United States. Savannas usually do not receive groundwater discharge, the soil moisture resulting from precipitation and retardation of downward percolation by a plinthite hardpan or other restrictive layers beneath the soil surface. Standing water may be present in the lowest areas after periods of heavy rainfall. Lateral movement of soil water may occur, but when it does it is much slower than in seepage bogs because slope is not as great. The length of the hydroperiod is dependent on the amount of rainfall. Soil moisture may therefore vary considerably during a season. Generally speaking, after rainless periods, savannas are drier than any other habitat types. Slight microtopographic differences within sites often create differences in the floristic composition, a fact also noted by Ajilvsgi (1976). It is for



this reason that lists of plants from savanna sites often include species that are not really typical of pitcher plant habitats in that they do not actually co-exist in microsyntopy with the characteristic floristic components of the pitcher plant community. As a result of gradual changes in elevation, the wetter savannas which harbor this community often grade into drier savannas that lack most of the floristic elements of pitcher plant habitats. It is therefore often difficult to perceive a sharp demarcation between the pitcher plant savanna and adjacent drier pine savannas. *Sphagnum* is usually not common in savanna habitats and is absent for many. When present, it often occurs in depressions or in the lowest areas. Wiregrass (*Aristida stricta*) is characteristic of pitcher plant savannas, but Walker and Peet (1983) found that it dominated only in sites drier than those which harbored *Sarracenia* species. Scattered trees are typical. Longleaf pine (*Pinus palustris*) is the most frequently encountered pine in pitcher plant savannas along the Gulf Coast, but in areas with a reduced fire frequency, both slash pine (*Pinus elliottii*) and, occasionally, loblolly pine (*P. taeda*) may be present. Along the Atlantic Coast, in southern Georgia, and in the eastern Florida Panhandle, pond pine, *Pinus serotina*) often occurs in savannas. Pond cypress (*Taxodium ascendens*) is sometimes present.

Species richness is higher in the flora of savannas than in any other pitcher plant habitat except seepage bogs. Walker and Peet (1983) noted that some of the sites they studied had small scale species richness greater than that reported for any other North American plant community. Plant density, however, tends to be lower in savannas than in most of the other habitat types. This is probably the result of their relative dryness during periods without rainfall. The largest savanna areas lie along the Gulf Coast, but considerable acreages also occur in Georgia and the Carolinas. In some areas, pockets of pitcher plant savanna occupy depressions in surrounding drier savannas or even amidst scrub and sandhill habitats. Burrowing crayfish may be present in the wettest areas but are rarely abundant. They are absent from many savannas.

### Swales (Fig. 8)

These habitats typically lie near the coast in areas where ridge and swale topography exists as a result of the presence of ancient or recent dunes or barrier island systems. They are rarely present in dune systems in inland areas. The depressions or swales are often wet during much of the year. Many have no surface drainage connections and permanent or semipermanent surface water may occupy the lowest areas. Flowing water is rarely present. Soil moisture in interdune swales is derived from precipitation and from contact with the true (rather than perched) water table. At times, sloping sandy areas at the edges of swales have restrictive layers in the soil and thus may resemble seepage or savanna habitats.





Fig. 8. A swale habitat in Escambia County, Florida. The visible pitcher plants are *Sarracenia leucophylla*, but *S. purpurea* and *S. psittacina* are also abundant. Low areas with standing water are occupied by *Hypericum fasciculatum*. The trees are mainly *Pinus elliotii*.

### Anthropogenic Habitats (Fig. 9)

Alteration of habitats by man has created areas where a number of the biotic components of pitcher plant habitats may occur even though the site may have originally been unsuitable. Included are roadside ditches, edges of artificial ponds and lakes, and depressions resulting from construction, quarrying, and mining activities. In some areas, such sites represent the only habitat remaining for species characteristic of wetland pyrogenic communities. In this classification, anthropogenic sites do not include natural habitats that have been merely disturbed or in which succession has been set back, only those resulting from alteration of previously unsuitable sites. Anthropogenic sites are most frequently found downslope or





Fig. 9. An anthropogenic pitcher plant habitat in Baldwin County, Alabama. *Sarracenia leucophylla* in early fruit is conspicuous. *Sarracenia psittacina* and *S. purpurea* are also abundant. The woody vegetation includes *Cliftonia monophylla*, *Chamaecyparis thyoides*, and *Pinus elliottii*.

downstream from a natural pitcher plant habitat. The diaspores of many of the species of this community are typically dispersed by rainwash hydrochory (Folkerts, unpublished information) and thus tend to aggregate in safe sites in the direction of flow. Some sites are remarkably speciose, but they invariably contain a variety of species from other wetland communities. One anthropogenic site in Baldwin Co., Alabama, harbors ten carnivorous plant species but also includes Atlantic white cedar (*Chamaecyparis thyoides*) and a number of other species not typical of natural pitcher plant communities.

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## Classification of Pitcher Plant Habitats

Of the habitats described here, by far the greatest acreages remaining are of savanna and seepage bog habitats. This was almost assuredly the case in pre-Columbian times and was probably true before humans arrived in the New World. Survival of these unique assemblages of organisms depends on the preservation of significant acreages of savanna and seepage bog habitat. The other habitat types are each unique in some respects, but occupy much smaller acreages or show much less diversity than the seepage bog and savanna types. Further investigations are urgently needed on many aspects of pitcher plant habitats, especially on successional phenomena, hydrology, nutrient dynamics, and phytogeography.

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### LITERATURE CITED

- Ajilvsgi, G. 1979. Wild flowers of the Big Thicket, east Texas, and western Louisiana. Texas A & M Univ. Press, College Station. 360 p.
- Allen, C. M., C. H. Stagg, and S. D. Parris. 1988. Analysis of the vegetation in pitcher plant bogs in two baygalls at Ft. Polk in west central Louisiana. *Proc. Louisiana Acad. Sci.* 50: 1-6.
- Allen, H. L., and R. G. Campbell. 1988. Wet site pine management in the southeastern United States. p. 173-184. *In* Hook, D. D., W. H. McKee, Jr., H. K. Smith, J. Gregory, V. G. Burrell, Jr., M. R. Devoe, R. E. Sojka, S. Gilbert, R. Banks, L. H. Storzy, C. Brooks, T. D. Matthews, and T. H. Shear. (eds.) *The ecology and management of wetlands. Vol. 2 Management, use, and value of wetlands.* Timber Press, Portland, Ore.
- Ajilvsgi, G. 1979. Wild flowers of the Big Thicket, east Texas, and western Louisiana. Texas A & M Univ. Press, College Station. 360 p.
- Allen, C. M., C. H. Stagg, and S. D. Parris. 1988. Analysis of the vegetation in pitcher plant bogs in two baygalls at Ft. Polk in west central Louisiana. *Proc. Louisiana Acad. Sci.* 50: 1-6.



- Allen, H. L., and R. G. Campbell. 1988. Wet site pine management in the southeastern United States. p. 173-184. *In* Hook, D. D., W. H. McKee, Jr., H. K. Smith, J. Gregory, V. G. Burrell, Jr., M. R. DeVoe, R. E. Sojka, S. Gilbert, R. Banks, L. H. Storzy, C. Brooks, T. D. Matthews, and T. H. Shears. (eds.) The ecology and management of wetlands. Vol. 2. Management, use, and value of wetlands. Timber Press, Portland, Ore.
- Barker, N. G. 1984. The effects of fire on pitcher plants in southern Louisiana: experimental evidence. M. S. Thesis. Louisiana State University. 46 p.
- Barker, N. G., and G. B. Williamson. 1988. Effects of a winter fire on *Sarracenia alata* and *S. psittacina*. Amer. J. Bot. 75: 138-143.
- Barry, J. M. 1980. Natural vegetation of South Carolina. Univ. of South Carolina Press, Columbia. 214 p.
- Bartram, W. 1791. Travels through North and South Carolina, Georgia, East and West Florida. Philadelphia. 414 p.
- Brickell, J. 1737. Natural history of North Carolina. Published by the author. Dublin, Ireland.
- Bridges, E. L., and S. L. Orzell. 1990. *Xyris chapmanii*, a new species from the Gulf Coastal Plain of the southern United States. Phytologia 68: 382-289.
- Christensen, N. L. 1977. Fire and soil-plant nutrient relationships in a pine-wiregrass savanna on the coastal plain of North Carolina. Oecologia 31: 27-44.
- Christensen, N. L. 1979. The xeric sandhill and savanna ecosystems of the southeastern Atlantic Coastal Plain, U.S.A. p. 246-262. *In* H. Lieth & E. Landholt (eds.) Contributions to the Knowledge of Flora and Vegetation in the Carolinas. Vol. 68, Veroff. Geobott. Inst. ETH, Stiftung Rubel, Zurich.
- Christensen, N. L. 1988. Vegetation of the southeastern Coastal Plain. p. 317-363. *In* M. G. Barbour and D. W. Billings (eds.) North American terrestrial vegetation. Cambridge University Press, New York.
- Clewell, A. F. 1971. The vegetation of the Apalachicola National Forest: an ecological perspective. U. S. Forest Service, Tallahassee, Fla. 162 p.
- Clewell, A. F. 1981. Natural setting and vegetation of the Florida Panhandle. Report prepared under contract No. DACWO1-77-C-0104 from the U.S. Army Corps of Engineers, Mobile, Ala. 773 p.

## Classification of Pitcher Plant Habitats

- Conde, L. F., J. E. Smith, and C. A. Hollis. 1979. Effects of intensive reforestation activities on higher plant species diversity and frequency on a coastal pine-cypress-titi site: first years results. IMPAC Report 2: 1-12. School of Forest Resources and Conservation, Univ. Florida.
- Coultas, C. L. 1976. Soils of the Apalachicola National Forest wetlands. Part I. Titi swamps and savannahs. *Proc. Soil Crop Soc. Fla.* 36: 72-77.
- Coultas, C. L., A. F. Clewell, and E. M. Taylor, Jr. 1979. An aberrant toposequence of soils through a titi swamp. *J. Soil Sci. Soc. Amer.* 43: 377-383.
- Crum, H. 1988. A focus on peatlands and peat mosses. Univ. Michigan Press, Ann Arbor. 306 pp.
- Dansereau, P. and F. Segadas-Vianna. 1952. Ecological study of the peat bogs of eastern North America. *Can. J. Bot.* 30: 490-520.
- Dyksterhuis, E. J. 1957. The savannah concept and its use. *Ecology* 38: 435-442.
- Eleutarius, L. N. 1968. Floristics and ecology of coastal bogs in Mississippi. Master's thesis. University of Southern Mississippi.
- Eleutarius, L. N., and S. B. Jones. 1969. A floristic and ecological study of pitcher plant bogs in south Mississippi. *Rhodora* 71: 29-34.
- Folkerts, G. W. 1982. The Gulf Coast pitcher plant bogs. *Am. Sci.* 70: 261-267.
- Gaddy, L. L. 1982. The floristics of three South Carolina Pine savannas. *Castanea* 47: 393-402.
- Gibson, T. C. 1983. Competition, disturbance, and the carnivorous plant community in the southeastern United States. Ph.D. thesis. University of Utah. 244 p.
- Gorham, E. 1957. The development of peat lands. *The Quarterly Review of Biology* 32: 145-166.
- Haddock, J. D., and R. L. Todd. 1982. Nitrogen fixation on floating peat masses of the Okefenokee swamp. p. 353-370. *In* Cohen, A. D., D. J. Casagrande, M. J. Andrejko, and G. R. Best (eds.). Okefenokee swamp: its natural history, geology, and geochemistry. Wetland Surveys, Los Alamos, N. M.
- Harper, R. M. 1906. A phytogeographical sketch of the Altamaha Grit Region of the Coastal Plan of Georgia. *Ann. N. Y. Acad. Sci.* 17: 1-415.

- Harper, R. M. 1922. Some pine-barren bogs in central Alabama. *Torrey* 22:57-60.
- Heinselman, M. L. 1963. Forest sites, bog processes, and peatland types in the glacial Lake Agassiz region, Minnesota. *Ecological Monographs* 33: 327-374.
- Hubbell, T. H., A. M. Laessle, and J. C. Dickenson, Jr. 1956. The Flint-Chattahoochee-Appalachicola region and its environments. *Bull. Florida State Mus.* 1: 1-72.
- Jones, R. H., and C. a. Gresham. 1985. Analysis of composition, environmental gradients, and structure in Coastal Plain lowland forests of South Carolina. *Castanea* 50: 207-227.
- Kologiski, R. L. 1977. The phytosociology of the Green Swamp, North Carolina. N. C. Ag. Expt. Sta. Tech. Bull. No. 250 100 pp.
- Kral, R. 1955. A floristic comparison of two hillside bog localities in northeastern Texas. *Field and Lab.* 23: 47-69.
- Larsen, J. A. 1982. Ecology of the northern lowland bogs and conifer forests. Academic Press, New York. 307 pp.
- MacRoberts, B. R., and M. H. MacRoberts. 1988. Floristic composition of two west Louisiana pitcher plant bogs. *Phytologia* 65: 184-190.
- MacRoberts, B. R., and M. H. MacRoberts. 1990. Vascular flora of two west Louisiana pitcher plant bogs. *Phytologia* 68: 271-275.
- MacRoberts, M. H., and B. R. MacRoberts. 1990. Size distribution and density of trees in bogs and pine woodlands in west central Louisiana. *Phytologia* 68: 428-434.
- McCaffrey, C. A., and D. B. Hamilton. 1984. Vegetation Mapping of the Okefenokee swamp ecosystem. p. 201-211. *In* Cohen, A. D., D. J. Casagrande, M. J. Andrejko, and G. R. Best (eds.). Okefenokee swamp: its natural history, geology, and geochemistry. Wetland Surveys, Los Alamos, N.M.
- McDaniel, S. 1971. The genus *Sarracenia* (Sarraceniaceae). *Bull. Tall Timbers. Res. Stn.*, no. 9, 1-38.



## Classification of Pitcher Plant Habitats

- Means, D. B. and P. E. Moler. 1978. The pine barrens treefrog: fire, seepage bogs, and management implications. p. 77-81. *In* Odom, R. R., and L. Landers (eds.). Proceedings of the Rare and Endangered Wildlife Symposium. Georgia Dept. Nat. Res., Atlanta.
- Nixon, E. S. and J. R. Ward. 1986. Floristic composition and management of east Texas pitcher plant bogs. p. 283-287 *In* Kulhavy, D. L., and R. N. Connor (eds.). Wilderness and Natural Areas in the Eastern United States. Stephen F. Austin State Univ., Nacogdoches, TX.
- Norquist, C. 1985. Savannas and bogs of the southeastern U. S.: threatened ecosystems. *Endangered Sp. Tech. Bull.* 10: 4-5.
- Novitzki, R. P. 1978. Hydrologic characteristics of Wisconsin's wetlands and their influence on floods, streamflow, and sediment. p. 377-388. *In* Greeson, P. E., J. R. Clark, and J. E. Clark (eds.). Wetland functions and values: the state of our understanding. Amer. Water Res. Assoc., Minneapolis.
- Osvald, H. 1970. Vegetation and stratigraphy of peatlands in North America. *Nova Acta Regiae Soc. Sci. Ups.*, C, 1, 96 pp.
- Penfound, W. T. 1952. Southern swamps and marshes. *The Botanical Review.* 18: 413-446.
- Penfound, W. T., and A. G. Watkins. 1937. Phytosociological studies in the pinelands of southeastern Louisiana. *Am. Mid. Nat.* 18: 661-682.
- Plummer, G. L. 1963. Soils of the pitcher plant habitats in the Georgia Coastal Plain. *Ecology* 44: 727-734.
- Porcher, R. D., Jr. 1966. A floristic study of the vascular plants in nine selected Carolina Bays in Berkeley County, South Carolina. M.S. Thesis. University of South Carolina, Columbia. 123 pp.
- Pullen, T. M., Jr., and G. L. Plummer. 1964. Floristic changes within pitcher plant habitats in Georgia. *Rhodora* 66: 375-381.
- Pulliam, H. R. 1988. Sources, sinks, and population regulation. *Am. Nat.* 132: 652-661.
- Roberts, P. R. & H. J. Oosting. 1958. Responses of Venus' flytrap (*Dionaea muscipula*) to factors involved in its endemism. *Ecol. Monogr.* 28: 193-218.

- Sandifer, P. A., J. V. Miglarese, D. R. Calder, J. J. Manzi, and L. A. Barclay. 1980. Ecological characterization of the Sea Island coastal region of South Carolina and Georgia. Vol. III: Biological features of the characterization area. U.S. Fish and Wildlife Service, Office of Biological Services, Washington, DC FWS/OBS-79/42. 620 pp.
- Schimper, A. F. W. 1903. Plant geography on a physiological basis. Clarendon Press, Oxford. 839 pp.
- Schnell, D. E. 1980. Notes on the biology of *Sarracenia oreophila* (Kearney) Wherry. *Castanea* 45: 166-170.
- Schnell, D. E. 1982. Effects of simultaneous draining and brush cutting on a *Sarracenia* L. population in a southeastern North Carolina pocosin. *Castanea* 47: 248-260.
- Sharitz, R. R., and J. W. Gibbons. 1982. The ecology of southeastern shrub bogs (pocosins) and Carolina bays: a community profile. U.S. Fish and Wildlife Service, Division of Biological Services, Washington, DC FWS/OBS-82/04. 93 pp.
- Streng, D. R., and P. A. Harcombe. 1982. Why don't East Texas savannas grow up to forest? *Amer. Midland Natur.* 108: 278-294.
- Telfair, R. C., II. 1988. Conservation of the Catfish Creek ecosystem: a national natural landmark in eastern Texas. *Texas J. Science* 40: 11-23.
- Walker, J. & R. K. Peet. 1983. Composition and species diversity of pine-wiregrass savannas of the Green Swamp, North Carolina. *Vegetatio* 55: 163-179.
- Weiss, E. W., Jr. 1980. The effects of fire and nutrient availability on the pitcher plant *Sarracenia flava* L. Ph.D. Thesis, University of Georgia, Athens, GA 100 p.
- Wells, B. W. 1967. The natural gardens of North Carolina. University of North Carolina Press, Chapel Hill. 458 p.
- Wells, B. W., and I. V. Shunk. 1928. A southern upland grass-sedge bog: an ecological study. *Ecol. Monog.* 1: 465-520.
- Wells, B. W., and L. A. Whitford. 1976. History of stream-head swamp forests, pocosins, and savannahs in the Southeast. *J. Elisha Mitchell Sci. Soc.* 92: 148-150.

## Classification of Pitcher Plant Habitats

- Wharton, C. H. 1977. The natural environments of Georgia. Georgia Dept. Nat. Res., Atlanta.
- Wherry, E. T. 1929. Acidity relations of the Sarracenias. J. Wash. Acad. Sci. 19: 379-390.
- Williams, J. L. 1827. A view of West Florida. Privately published by H. S. Tanner and J. L. Williams. Philadelphia. 178 p.
- Winner, M. D., Jr., and C. E. Simmons. 1977. Hydrology of the Creeping Swamp watershed, North Carolina, with reference to potential effects of stream channelization. U. S. Geological Survey Water Resources Investigations 77-26. 54 pp.
- Wolfe, S. H., J. A. Reidenauer, and D. B. Means. 1988. An ecological characterization of the Florida Panhandle. U. S. Fish Wildl. Serv. Biol. Rep. 88(12); Minerals Manage. Serv. OCS Study/MMS 88-0063; 277 pp.
- Wright, A. H., and A. A. Wright. 1932. The habitats and the composition of the vegetation of Okefenokee Swamp, Georgia. Ecol. Monogr. 2: 190-232.



## A COMPARISON OF NOCTURNAL HEAT ISLAND OBSERVATIONS AT TUSCALOOSA, ALABAMA AND ATHENS, GEORGIA<sup>1</sup>

Peter T. Soulé and Thomas B. Pugh  
*Department of Geography*  
*The University of Alabama*  
*Tuscaloosa, Alabama 35487-0322*

### INTRODUCTION

One of the best observed aspects of human impact on climate is the urban heat island (UHI). The term "heat island" refers to the typical pattern of temperature which develops over urban areas and their surrounding environs. In a classic heat island, temperatures are elevated over central business district (CBD) areas, then gradually decline through residential areas and fall sharply as the landscape becomes rural (Friskin, 1973, Oke, 1978). The interaction of various mechanisms within urban areas, such as large releases of anthropogenic heat, reduced sky-view factor, reduced evapotranspiration rates, increased surface roughness, and greater thermal conductivity of building materials, leads to the development of this phenomenon (Oke, 1975; Carnahan and Larson, 1990).

Consequences of a heat island can be both positive, such as a slightly longer growing season, and negative, such as increased human heat stress during the summer months. In instances where the heat island is particularly well developed other aspects of the urban climate (e.g. air circulation) can also be impacted (Lee, 1977). Negative effects of heat islands have been partially overcome by the planned use of greenspace and parks to provide cooler pockets of air within urban environments (Suckling, 1981).

While the urban heat island is best developed over large urban areas, the phenomenon has been investigated for a number of smaller cities (e.g. Duckworth and Sandberg, 1954, Kopec, 1970, Suckling, 1981, Travis et al. 1987). Oke (1973) analyzed data from a number of different sized cities and found a strong positive curvilinear relationship between the population of an urban area and the magnitude of the heat island. In most research the strength of the heat island is measured by the difference between extreme urban and rural temperature readings. For urban areas with populations below 50,000 the urban-rural temperature differences are often 4 - 6 °C on clear nights while cities with populations of 100,000 or more may experience differences of between 10 - 12 °C (Oke, 1973, Suckling, 1981).

This study is designed to investigate various questions concerning the urban heat island effect in medium sized cities (population between 50,000 and 100,000): 1) do observable heat islands exist over Tuscaloosa, Alabama and Athens, Georgia during spring and autumn months, 2) what is the magnitude of the heat islands and is the magnitude equivalent between cities, 3) does the heat island effect result in significant nocturnal boundary layer temperature differences among various land use categories within the urban areas and their surrounding environs, and 4) what is the relationship between local topography and the urban heat island at these two cities.

## METHODS AND MATERIALS

Data for this study were collected within the Athens and Tuscaloosa urban areas and their surrounding environs (Figure 1). Athens is a small urban center located within the Georgia Piedmont. The climate of Athens is humid subtropical, with an average yearly rainfall of 1220 mm and average temperatures ranging from 7 °C in January to 26 °C in July. The climate of Tuscaloosa is also humid subtropical, with an average yearly rainfall of 1346 mm and average temperatures ranging from 6 °C in January to 27 °C in July. Both Tuscaloosa and Athens are educational and service oriented cities with metropolitan area populations of under 100,000.



Fig. 1. Location of Tuscaloosa, Alabama and Athens, Georgia.

## Comparison of Nocturnal Heat

Temperature data for Athens were gathered with a DigiSense<sup>™</sup> thermistor thermometer mounted on an automobile. The instrument allows readings to be taken at a resolution of 0.1 °C and has an estimated accuracy of  $\pm 0.6$  °C. Temperature data for Tuscaloosa were collected with a Yellow Springs<sup>™</sup> Telethermometer which has a resolution of 0.5 °C. Temperatures were interpolated to the nearest 0.1 °C. A quick response probe was utilized on both instruments. The probe was placed within a radiation shield and mounted on the vehicle's outside rear view mirror at approximately 1.1m above the ground. Air flow over the sensor was held constant by taking all readings while the vehicle was moving at 40-50 km/hr (25-30 mph).

For Athens, data were collected at 33 predetermined points along a 16km transect which runs roughly north to south and is centered on the CBD. Elevation changes along the transect ranged from 195 meters in the rural areas north of Athens to around 235 meters in the CBD. A north-south transect was also used for Tuscaloosa. The Tuscaloosa transect covered 29 km and had 31 preselected observation points. The Tuscaloosa transect was nearly inverse of that for Athens, with minimum elevations of between 52 and 66 meters in the urban areas and maximum elevations of over 100 meters in the rural environs.

The transects were traversed in both directions, with temperature data collected on the initial and return trip. These values were then averaged so that any temporal changes in ambient air temperature which occurred during the 1 to 1 1/2 hours needed to complete the traverse were filtered out.

Urban heat islands are generally best developed on calm, clear nights (Oke, 1978). Observations for this study were taken on eight nights with calm to light winds. Two predominately clear nights and two overcast nights were selected for each location. Examining the data from more than one clear and cloudy night served as a control against aberrant microclimatological conditions. Data for all nights were gathered approximately 3-4 hours after sunset. Meteorological conditions for Athens and Tuscaloosa (cloud cover and wind velocity) encountered during the times of data collection were obtained from the National Weather Service.

The transect routes pass through four highly generalized land use categories. These land use types are rural, residential, institutional, and urban (CBD). For Athens, ten observation points were located in each of the rural, residential, and urban areas with the remaining three in institutional areas (University of Georgia Campus). For Tuscaloosa, there were ten observations in rural areas, seven in residential, and fourteen in urban areas. The land use categories chosen for this study roughly conform to those recognized by Athens-Clarke County Planning Commission and Tuscaloosa Community Planning and Development Department. Rural areas are characterized by open fields or forests with man-made structures sparsely distributed. Residential areas are those dominated by single or multifamily homes. The CBD is a commercial area dominated by tightly spaced brick structures of between two and



ten stories. The institutional land use represents the University of Georgia campus, which has numerous brick structures widely spaced within a well vegetated area.

At each measurement location, elevation was interpolated from U.S.G.S. 7.5 minute topographic maps. Correlation analysis was used to determine the relationships between elevation and temperature. Elevation data are also presented graphically along with observed temperature data for each observation along the transect.

The magnitude of the heat island for Tuscaloosa and Athens was determined in two ways. First, the standard measure of heat island magnitude was calculated. This is simply the difference between the extreme (individual) urban versus rural temperature readings ( $\Delta T_{u-r}$ ). Since this technique may tend to overestimate the development of a heat island, a second measure of magnitude was calculated. This second measure represents the difference between the average urban and average rural conditions ( $\Delta T_{u-r}$ ).

Analysis of Variance (ANOVA) was used to determine if significant differences in temperature exist among the three primary land use categories for each of the eight nights of observation. When significant F ratios were found at the 0.05 level, a Scheffe post-hoc analysis was performed to identify the specific land use category differences.

Observed temperature and elevation data for Athens are presented in Figure 2. For both clear nights, the urban heat island is apparently well developed (Figure 2a). Although the average temperature values were considerably different on these two nights, the changes in temperature with distance are nearly identical. The observed pattern of temperature changes conforms to the expected patterns for urban heat islands (Oke, 1978). Temperature values are initially low in the rural areas south of the CBD. Steady, but small increases in temperature occur through much of the residential area, with sharp increases just prior to the University of Georgia (UGA) campus. Temperatures continue to climb through the UGA campus, reaching maximum values within the urbanized CBD. Considerable variability in ambient air temperature exists within the CBD. Part of this is due to the heterogeneous makeup of downtown Athens (i.e. building size and structure is highly variable). Some of the fluctuations in the recorded urban air temperature can also be attributed to the circular transect route taken through the CBD. Temperature changes on the north side of the CBD are more drastic. Temperatures decline sharply through the residential areas into the rural areas. Part of this decline is likely a function of topography, as the residential and some of the rural areas north of the CBD are at lower elevations than their counterparts on the southern side, making them susceptible to cold-air drainage. The lowest temperature values along the transect were consistently observed in the northern rural areas.

## Comparison of Nocturnal Heat

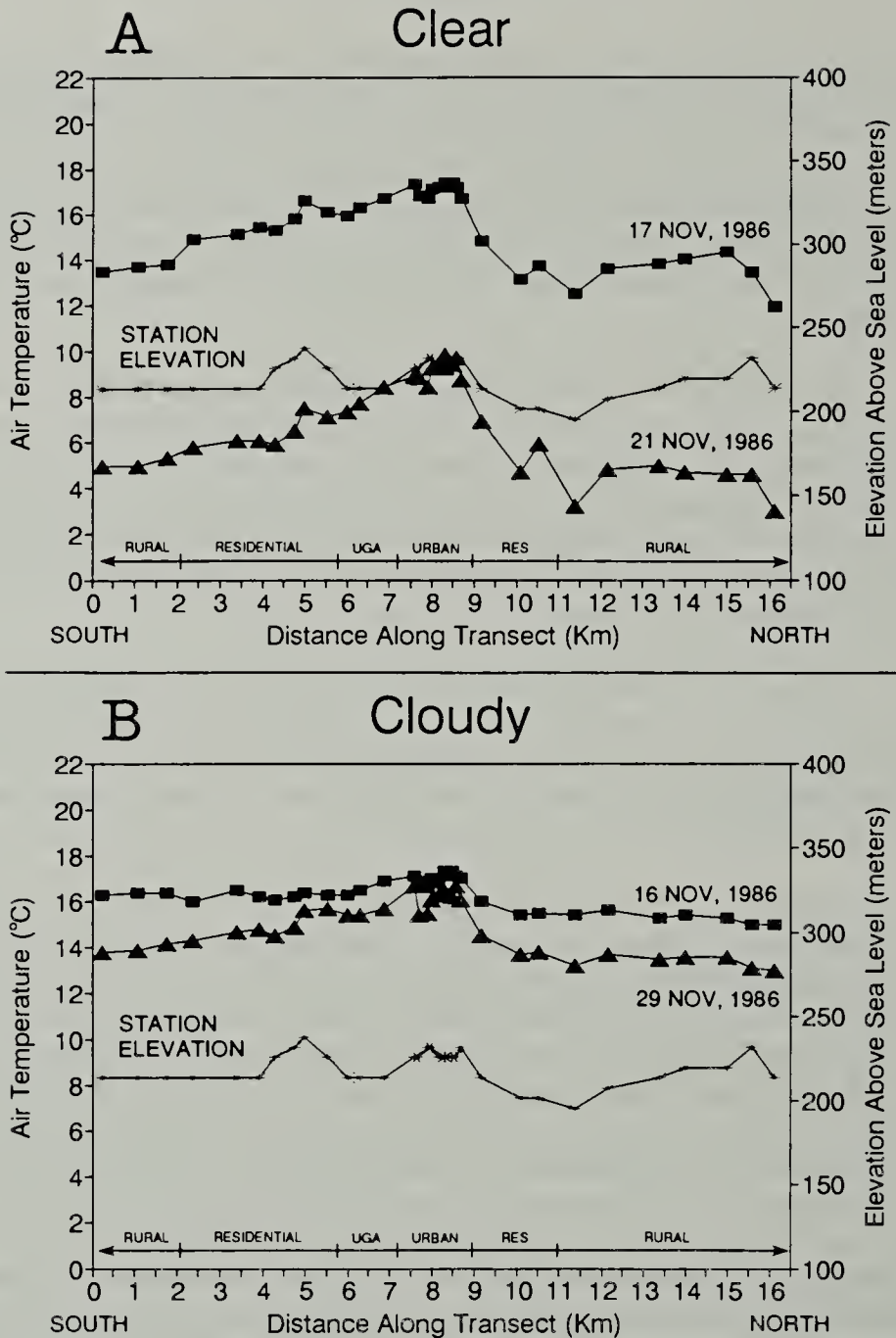


Fig. 2. Observed temperatures for clear (A) and cloudy (B) observation nights and corresponding elevations along the transect route for Athens, Georgia.

Figure 2b displays the temperature patterns for the two cloudy nights. As expected, there is considerably less variability along the transect under overcast skies. However, the heat island is still easily observed and the general patterns are similar to those for clear conditions.

The two measures of heat island magnitude are presented along with the cloud cover and wind speed data for Athens in Table 1. Using the conventional measure of heat island magnitude ( $\Delta T_{u-r}$ ), all of the values fall between 2 and 7 °C. This range is similar to observed magnitude ranges in cities with the same population, and to previous observations of the UHI in Athens (Suckling, 1981; Travis et al. 1987). Using the more conservative measure of heat island magnitude ( $\Delta T_{u-r}$ ) reduces the range of observations to between 1 and 5 °C. Considering the variability within each of the land use categories (both topographic and cultural), this measure probably provides for a more accurate representation of the heat island magnitude.

Table 1. Heat Island Magnitude and Meteorological Data at 2000 est on 16, 17, 21, and 29 November, 1986 for Athens, Georgia

Date (1986)	Cloud Conditions	Average Windspeed (m s <sup>-1</sup> )	$\Delta T_{u-r}$ (°C)	$\Delta T_{u-r}$ (°C)
Nov. 16	overcast	1.3	2.4	1.4
Nov. 17	clear w/scattered clouds	1.3	5.6	3.7
Nov. 21	clear	4.1	6.8	4.6
Nov. 29	overcast	2.2	3.8	2.7

The relationship between windspeed and heat island magnitude is opposite to that expected. In theory, as wind increases so does the mixing of air in the boundary layer. This mixing should result in more even temperature distributions across horizontal distances. The greatest heat island magnitude for Athens was observed on 21 November, the night with the strongest average winds. This apparent discrepancy is most likely linked to daytime meteorological conditions. On 21 November skies were clear throughout the day. On 17 November, the other clear night, it was partly cloudy until mid afternoon. This, in combination with a few scattered clouds on the 17th, can readily account for the differences in magnitude on the clear nights. The same reasons can be used to account for magnitude differences on the cloudy nights, since 16 November was cloudy the entire day while on 29 November it was clear until early afternoon. Thus, the development of a nocturnal heat island can be partially linked to the amount of incoming solar radiation received during the daytime hours.



## Comparison of Nocturnal Heat

Simple correlations between elevation and temperature reveal moderately positive relationships for Athens (Table 2). Although as much as 44% of the variance in temperature can be statistically explained by elevation changes, it is realistically impossible to determine how much of the urban-rural temperature difference is directly attributable to elevation, and how much is caused by the UHI effect. As previously noted, the design of the Athens area, with the CBD located on a hill, should tend to enhance the urban-rural temperature differences.

Table 2. Simple Correlations\* between Elevation and Temperature along the Transect Route for Athens, Georgia

Date & Conditions	Simple r	R <sup>2</sup>
Nov. 16 (cloud)	0.49	0.24
Nov. 17 (clear)	0.67	0.45
Nov. 21 (clear)	0.60	0.36
Nov. 29 (cloudy)	0.59	0.35

\*All correlations are significant at the 0.05 level.

All ANOVA tests were conducted with a null hypothesis of no significant differences in boundary layer air temperatures over different land use types. The institutional (UGA campus) category was not tested due to a lack of observation sites. Since all ANOVA tests revealed significant differences in boundary layer air temperature among land use types, the Scheffe post-hoc test was used to determine where the differences occurred. The ANOVA results for Athens are presented in Table 3. With one exception, the data indicate that significant differences in nocturnal boundary layer air temperatures exist among all land use categories on each of the four study nights. The one exception occurs on November 16, a cloudy night with a weakly developed urban heat island effect (Table 1). The findings were somewhat surprising as differences between residential and rural locations were not expected to be significant. Also interesting is the fact that temperatures were significantly different even under cloudy conditions when the heat island magnitude was not pronounced.

Table 3. ANOVA Results for the Comparison of Air Temperatures among Different Land Use Types at Athens, Georgia

Date & Conditions	Overall F-value*	Land Use Comparison using Scheffe-post-hoc Test*		
		Urban/Rural	Urban/Res.	Rural/Res.
Nov. 16 (cloudy)	22.9	Y	Y	N
Nov. 17 (clear)	43.4	Y	Y	Y
Nov. 21 (clear)	80.6	Y	Y	Y
Nov. 29 (cloudy)	50.1	Y	Y	Y

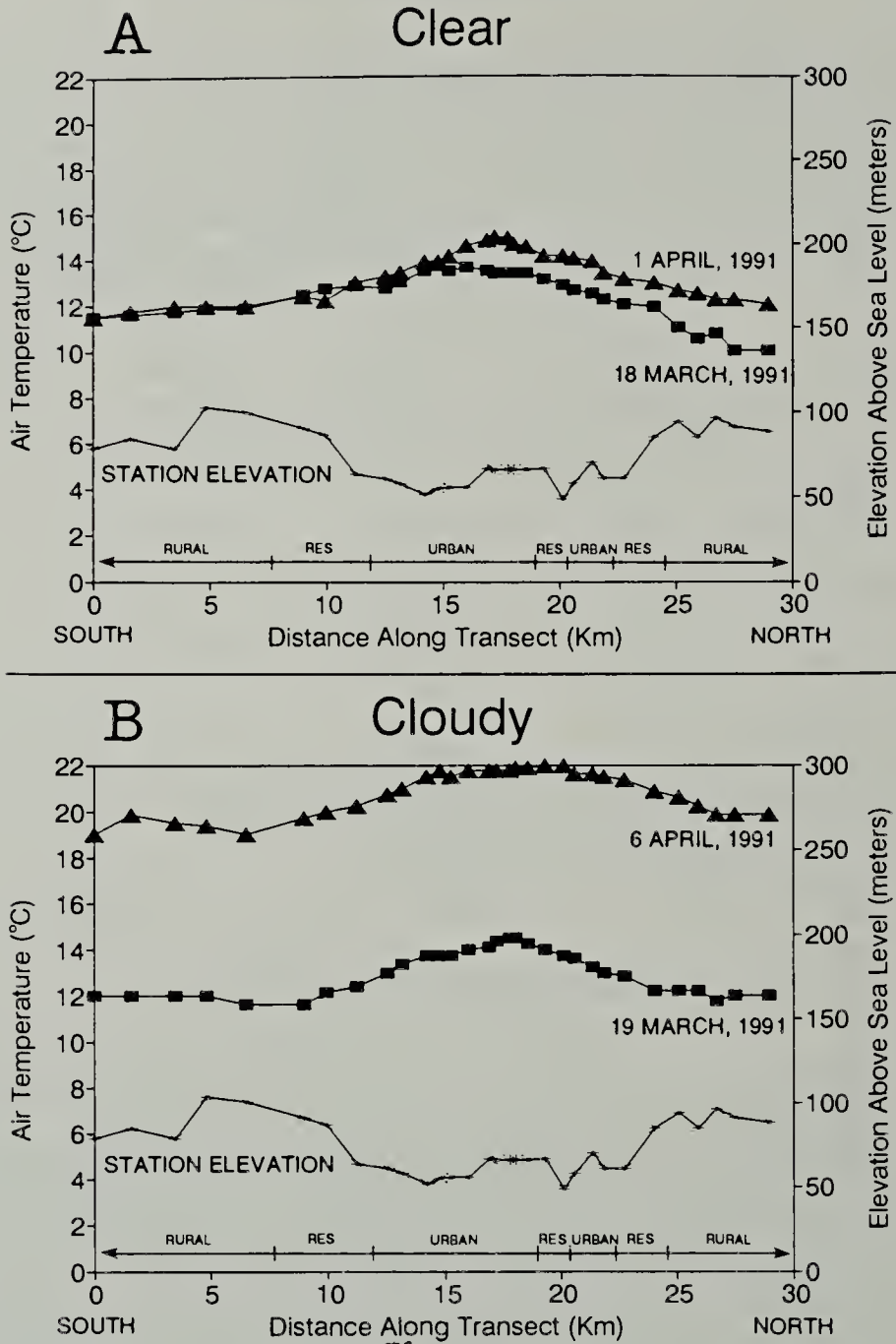
\*significance level set at 0.05 for the Scheffe test; overall F-values are all significant at the 0.0001 level

### RESULTS FOR TUSCALOOSA

Topographic cross sections of the transect route and corresponding temperature measurements for clear and cloudy observations nights in Tuscaloosa are presented in Figure 3. The heat island magnitude and meteorological conditions are given in Table 4. As with Athens, spatial patterns of temperature change for the Tuscaloosa area conform to the expected patterns for urban heat islands (Oke, 1978). On all four nights temperatures are comparatively low in the rural areas south of town, rise steadily in the urban area and CBD, then fall once again into the rural areas north of town. Although the magnitude of the UHI varies from night to night, the shape of the temperature trend line remains stable. This is especially evident on the two cloudy nights, which produced very similar trend lines and magnitudes despite differences in ambient air temperatures of 7-8 °C.

The overall and average UHI magnitude for the four nights of observation in Tuscaloosa (Table 4) were less (on average) than those observed in Athens (Table 1) and fell within a smaller range. The magnitude of the Tuscaloosa UHI may be less than city size and structure density would dictate due to the comparatively low

## Comparison of Nocturnal Heat



**Fig. 3.** Observed temperatures for clear (A) and cloudy (b) observation nights and corresponding elevations along the transect route for Tuscaloosa, Alabama.

elevations of the urban area relative to the surrounding area. The Tuscaloosa urban area is located on both sides of the Black Warrior River, resulting in low elevations in the urban area. The elevation transect for Tuscaloosa is nearly inverse of that for



Table 4. Heat Island Magnitude and Meteorological Data at 2000 cst on 18 and 19 March, and 1 and 6 April, 1991 for Tuscaloosa, Alabama

Date (1991)	Cloud Amount	Average Windspeed (m s <sup>-1</sup> )	$\Delta T$ u-r (C°)	$\Delta T$ u-r (C°)
Mar. 18	clear to partly cloudy	1.7	3.7	2.1
Mar. 19	partly cloudy	1.3	2.9	1.8
Apr. 1	clear to partly cloudy	calm	3.4	2.1
Apr. 6	mostly cloudy	1.3	3.0	1.8

Athens (Figure 2), where the urban area is located on a hill. Cold air drainage into the lower elevations of the Tuscaloosa urban area almost certainly reduces the magnitude of the UHI. Proving this would be difficult, especially since there is a relatively strong negative relationship between elevation and temperature for Tuscaloosa and the surrounding environs on all four study nights (Table 5). If topography were held constant, heat island magnitudes of near 8 °C might be expected for Tuscaloosa using Oke's (1973) regression equation.

Table 5. Simple Correlations\* between Elevation and Temperature along the Transect Route for Tuscaloosa, Alabama

Date & Conditions	Simple r	R <sup>2</sup>
Mar. 18 (clear)	-0.73	0.53
Mar. 19 (cloudy)	-0.80	0.64
Apr. 1 (clear)	-0.76	0.58
Apr. 6 (cloudy)	-0.80	0.364

\*All correlations are significant at the 0.05 level.

## Comparison of Nocturnal Heat

Despite the reduced magnitude of the Tuscaloosa UHI (compared to Athens), all ANOVA tests revealed significant differences in boundary layer air temperatures among land use types (Table 6). The Scheffe post-hoc test results reveal that significant differences exist among almost all land use category comparisons on all four study nights. The one exception was for the clear night of March 18, where no significant difference was found between urban and residential areas.

Table 6. ANOVA Results for the Comparison of Air Temperatures among Different Land Use Types at Tuscaloosa, Alabama

Date & Conditions	Overall F-value*	Land Use Comparison using Scheffe-post-hoc Test (Y = significant difference, N = no significant difference)		
		Urban/ Rural	Urban/ Res.	Rural/ Res.
Mar. 18 (clear)	39.4	Y	N	y
Mar. 19 (cloudy)	33.1	Y	Y	Y
Apr. 1 (clear)	40.0	Y	Y	Y
Apr. 6 (cloudy)	31.0	Y	Y	Y

\*significance level set at 0.05 for the Scheffe test; overall F-values are all significant at the 0.0001 level

## CONCLUSIONS

Results of this study indicate that Athens, Georgia and Tuscaloosa, Alabama can experience well developed urban heat islands during autumn and spring months. For both cities the observed pattern of temperature changes along a transect passing through the CBD conforms to the expected pattern of a generalized urban heat island. Despite variability in meteorological conditions, this typical pattern (rising temperatures into the CBD, then falling) developed on all study nights.

Results from the correlation analysis between elevation and temperature show that the topographic layout of a city can influence the urban heat island. Significant

positive correlations were found for Athens, negative correlations for Tuscaloosa. The impact of cold air drainage likely serves to enhance the UHI effect in Athen, and decrease the effect in Tuscaloosa.

As measured by extreme values, the magnitude of Athens' heat island on days of observation ranged from 2.4 to 6.8 °C. When using an average measure of heat island magnitude, the range decreases to between 1.4 and 4.6 °C. For Tuscaloosa the extreme ranges observed fall between 2.9 and 3.7 °C, and averaged magnitude from 1.8 to 2.1 °C. These results suggest that an averaged measure of heat island magnitude more accurately portrays the actual conditions encountered within a given land use category.

Results from the ANOVA tests indicate that changes in generalized land use significantly affect nocturnal boundary layer air temperatures. While significant differences in nocturnal air temperatures between urban and rural locations were expected, significant differences between residential and rural locations, even under overcast skies, were surprising. Further observations are needed to determine whether the relationships between boundary layer air temperature and land use type remain significant over varying meteorological conditions.

#### LITERATURE CITED

- Carnaham, W. H. and Larson, R. C. 1990. "An Analysis of an Urban Heat Sink," *Remote Sensing of the Environment*. 33: 65-71.
- Duckworth, F. and Sandberg, J. 1954. "The Effect of Cities upon Horizontal and Vertical Temperature Gradients," *Bulletin of The American Meteorological Society*. 35: 198-207.
- Friskien, W. 1973. *The Atmospheric Environment*. Baltimore: The Johns Hopkins University Press.
- Kopec, R. J. 1970. "Further Observations of the Urban Heat Island in a Small City," *Bulletin of the American Meteorological Society*. 51: 602-606.
- Lee, D. 1977. "Urban Influence on Wind Direction Over London," *Weather*. 32: 162-170.
- Oke, T. R. 1973. "City Size and the Urban Heat Island," *Atmospheric Environment*. 7: 769-779.
- Oke, T. R. 1975. "Urban Heat Island Dynamics in Montreal and Vancouver," *Atmospheric Environment*. 9: 191-200.
- Oke, T. R. 1978. *Boundary Layer Climates*. London: Methuen & Co.



## Comparison of Nocturnal Heat

- Suckling, P. W. 1981. "Nocturnal Heat Island Observations for Small Urban Centers," *Geographical Perspectives*. 48 (Fall, 1981): 35-41.
- Travis, D. J., Meentemeyer, V. and Suckling, P. W. 1987. "Influence of Meteorological Conditions on Urban/Rural Temperature and Humidity Differences for a Small City," *Southeastern Geographer*. 27: 90-100.

## CHECKLIST AND BIBLIOGRAPHY OF THE MOSQUITOES (DIPTERA: CULICIDAE) OF ALABAMA<sup>1</sup>

Lawrence J. Hribar<sup>2</sup>, Gary R. Mullen, and C. Steven Murphree  
*Department of Entomology and Alabama Agricultural  
Experiment Station  
Auburn University, AL 36849-5413*

### ABSTRACT

The literature pertaining to the mosquito fauna of Alabama is reviewed, and a list of mosquitoes occurring in the state is presented. Many species were first collected during military surveys in the World War II period. Other species were first recorded during early mosquito control work by the Tennessee Valley Authority in the northern part of the state. Fifty-six species and four subspecies of mosquitoes are reported from Alabama.

### INTRODUCTION

Mosquitoes are vectors of a number of human disease agents which have had a significant impact on the history of Alabama (Mullen and Hribar 1988). Despite the medical importance of mosquitoes, a comprehensive treatment of the mosquito fauna of Alabama has not been published. Herein a list of Alabama mosquitoes is presented, together with a short summary of literature pertaining to the state's mosquito fauna. The intent is to provide a general literature review of Alabama mosquitoes and a checklist of mosquito species of entomologists and public health workers in the state. Table 1 list 56 species and 4 subspecies for mosquitoes recorded in Alabama, along with the author(s) who first reported each taxon. Presence of voucher specimens in the collections at Auburn University and the Tennessee Valley Authority (TVA) at Muscle Shoals is indicated by footnotes. All generic abbreviations follow Reiner (1975).

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<sup>1</sup>Manuscript received 16 July 1991; accepted 13 August 1991.

<sup>2</sup>Present address: Department of Entomology, Louisiana State University, 402 Life Sciences Building, Baton Rouge, LA 70803.

## REVIEW OF LITERATURE

Dyar (1923, 1928) and Howard et al. (1912, 1915, 1917) were among the first to report mosquito collections from Alabama in their taxonomic compendia of North American culicids. Other workers emphasized public health and control of *Anopheles* mosquitoes, including Griffiths (1927), Guyton (1935), and Russell (1925).

During and shortly after World War II, several additions to the Alabama mosquito fauna were made by various authors. These were mostly new records detected through routine mosquito surveillance at military bases in the state. Bradley et al. (1944) first reported *Aedes fulvus pallens* Ross from the state. Carpenter (1945) recorded *Culex tarsalis* Coquillett from Calhoun, Etowah, Montgomery, and St. Clair counties. Carpenter and Middlekauf (1944) recorded *Anopheles atropos* Dyar and Knab from Dothan, *Ae. sollicitans* Walker from Montgomery, and *Ae. taeniorhynchus* (Wiedemann) from Attalla. Carpenter and Chamberlain (1946) made mosquito collections in the following localities in Alabama: Aliceville, Anniston, Attalla, Courtland, Dothan, Huntsville, Montgomery, Opelika, Ozark, Selma, and Tuskegee. King and Bradley (1941) reported on the occurrence of several species of *Anopheles* in Alabama. King et al. (1943) published new county records for some common mosquitoes. Miles and Rings (1946) first reported *Ae. cinereus* Meigen from Alabama and also provided new county records for other species. Rings and Hill (1948) clarified the taxonomy of the subspecies of *Ae. canadensis* (Theobald) and reported that both subspecies were present in the state. Wanamaker et al. (1944) discussed the taxonomy of the *Cx. pipiens* complex in Alabama. Bargren (1951, 1953, 1958) and Miles and Hill (1948) compiled further records of mosquitoes impacting military operations in Alabama.

The Tennessee Valley Authority was responsible for further research on Alabama mosquitoes in conjunction with their malaria control programs during the early part of the century. This included works by Breeland et al. (1961), Shields (1938), Shields and Miles (1937), Snow (1949), Snow and Smith (1956), Snow and Pickard (1956), and Watson and Spain (1937).

Other works dealing with mosquitoes collected in Alabama include Barr (1957), Belkin and Heinemann (1975), Darsie and Williams (1976), Floore et al. (1976), Jenkins (1949), King et al. (1960), Michener (1945), O'Meara and Craig (1970), Stojanovich (1960), and Zavortink (1972). Although Johnson and Harrell (1980) reported *Ae. trivittatus* as a new state record, this species had been reported earlier by Breeland et al. (1961).

In 1986, *Aedes albopictus* (Skuse) was discovered for the first time at two locations in Alabama, Muscle Shoals (Colbert Co.) and (Cullman Co.) (Anonymous (1986). Since that time, it has been reported from seven other Alabama counties (Covington, Etowah, Jefferson, Madison, Mobile, Montgomery, and Washington) ranging from the Gulf Coast to the Tennessee border (Anonymous 1990). Known as



the Asian tiger mosquito or the forest day mosquito, this species is particularly important from a public health viewpoint because of its potential as a vector of Dengue and Lacrosse viruses. It is effectively displacing *Ae. aegypti* L. in the southern part of its range where both species compete for tree holes and artificial containers in which they breed.

What was previously recognized as *Anopheles quadrimaculatus* Say is now regarded to be a complex of 4 sibling species (Kaiser et al. 1988, Narange et al. 1989). Species A and B have been documented in Alabama based on collections at Guntersville Reservoir, Marshall County, and 15 mi. east of Montgomery, Montgomery County (Lanzaro et al. 1990). Although morphologically indistinguishable from one another, the two species are now recognized on the basis of mating compatibility (Lanzaro et al. 1988) and genetic differentiation (Lanzaro et al. 1990). Darsie and Ward (1989) have reviewed the changes in nomenclature of this species complex.

### DUBIOUS RECORDS

Carpenter and Chamberlain (1946) reported the presence of *Psorophora confinnis* (Lynch-Arribalzaga) in Alabama. However, according to Belkin et al. (1970), the taxonomic status of the species in the *Psorophora confinnis* complex was unresolved at that time. Bickley (1976) reported that he had received a personal communication from Belkin in which it was recommended that specimens from the eastern United States be referred to as *Ps. columbiae* (Dyar and Knab), while those in the western United States be considered *Ps. confinnis*. Darsie (1978) and Darsie and Ward (1981) followed this recommendation in their works. *Psorophora confinnis* therefore is not included in our list of Alabama mosquitoes.

Although reports that *Psorophora varipes* (Coquillett) occurs in Alabama can be found in the older literature (e.g., King et al. 1960), Belkin and Heinemann (1975) hold that specimens from the southeastern United States are a distinct species, *Ps. mathesoni* Belkin and Heinemann.

*Psorophora signipennis* (Coquillett) was first reported in Alabama by Snow (1951). Breeland et al. (1961) stated that the occurrence of this species in Alabama is "questionable," and that the records are "unsubstantiated." The original collection data indicated that adults were collected from the Pickwick and Wheeler reservoirs in northern Alabama in 1936. A search of the mosquito collections at Auburn University and the Tennessee Valley Authority at Muscle Shoals failed to reveal any voucher specimens. According to Darsie and Ward (1981), *Ps. signipennis* is a western species which does not occur in Alabama.

Middlekauf and Carpenter (1944) collected a single specimen of *Mansonia titillans* (Walker) from Grand View Park, near Montgomery, Alabama. This specimen was later lost, and the specific identification was never confirmed

(Carpenter et al. 1946). Pratt (1945, 1953) stated that most records of *Ma. titillans* from North America are actually *Ma. indubitans* Dyar and Shannon. However, this latter species is entirely Neotropical in distribution, and in the United States *Ma. titillans* occurs only in Florida and Texas (Knight and Stone 1977).

### ACKNOWLEDGMENTS

We thank Eugene Pickard, Tennessee Valley Authority, Muscle Shoals, who assisted us in examining material in the TVA mosquito collection; William E. Johnson, Jr., Tuskegee University, Tuskegee, for information on specimens he and his research group have collected in recent years; and J.A. Seawright, Insects Affecting Man and Animals Laboratory, Gainesville, FL, for characterization of the *Anopheles quadrimaculatus* complex. AAES Journal No. 17-912917P.

Table 1. Checklist of Mosquitoes Reported From Alabama

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Subfamily Anophelinae
Genus <i>Anopheles</i> Meigen
<i>An. atropos</i> Dyar and Knab (Griffitts 1927)
<i>An. barberi</i> . Coquillett (King and Bradley 1941) <sup>a</sup>
<i>An. bradleyi</i> King (King and Bradley 1941)
<i>An. crucians</i> Wiedemann (Carpenter and Chamberlain 1946) <sup>a,b</sup>
<i>An. georgianus</i> King (Carpenter and Chamberlain 1946)
<i>An. perplexens</i> Ludlow (Russell 1925)
<i>An. punctipennis</i> (Say) (Carpenter and Chamberlain 1946) <sup>a,b</sup>
<i>An. quadrimaculatus</i> Say (sensu lato) (Carpenter and Chamberlain 1946) <sup>a,b</sup>
<i>An. quadrimaculatus</i> complex sp. A (Narang et al. 1989)
<i>An. quadrimaculatus</i> complex sp. B (Narang et al. 1989)
<i>An. walkeri</i> Theobald (Carpenter et al. 1945) <sup>a</sup>

(Table 1 continued)

Subfamily Culicinae

Genus *Aedes* Meigen

- Ae. aegypti* (L.) (Dyar 1923)<sup>a,b</sup>
- Ae. albopictus* (Skuse) (Anonymous 1986)
- Ae. atlanticus* Dyar and Knab (Guyton 1935)<sup>a,b</sup>
- Ae. atropalpus* (Coquillett) (Zavortink 1972)<sup>a,b</sup>
- Ae. canadensis canadensis* (Theobald) (King et al. 1943)<sup>a,b</sup>
- Ae. canadensis mathesoni* Middlekauf (Rings and Hill 1948)
- Ae. cinereus* Meigen (Miles and Rings 1946)<sup>a,b</sup>
- Ae. dupreei* (Coquillett) (Shields 1938)<sup>a,b</sup>
- Ae. fulvus pallens* Ross (Middlekauf and Carpenter 1944)<sup>a</sup>
- Ae. hendersoni* Cockerell (Zavortink 1972)
- Ae. infirmatus* Dyar and Knab (Carpenter and Chamberlain 1946)<sup>a</sup>
- Ae. mitchellae* (Dyar) (Dyar 1923)<sup>a</sup>
- Ae. sollicitans* (Walker) (King et al. 1944)<sup>a,b</sup>
- Ae. sticticus* (Meigen) (King et al. 1943)<sup>a,b</sup>
- Ae. taeniorhynchus* (Wiedemann) (Dyar 1928)
- Ae. thibaulti* Dyar and Knab (Shields and Lackey 1938)<sup>a</sup>
- Ae. tormentor* Dyar and Knab (Shields 1938)<sup>a</sup>
- Ae. triseriatus* (Say) King et al. 1944)<sup>a,b</sup>
- Ae. trivittatus* (Coquillett) (Breeland et al. 1961)<sup>a,b</sup>
- Ae. vexans* (Meigen) (Carpenter and Chamberlain 1946)<sup>a,b</sup>



(Table 1 continued)

Genus *Coquillettidia* Dyar

*Cq. perturbans* (Walker) (Carpenter and Chamberlain 1946)<sup>a,b</sup>

Genus *Culex* L.

*Cx. erraticus* (Dyar and Knab) (Carpenter and Chamberlain 1946)<sup>a,b</sup>

*Cx. nigripalpus* Theobald (Carpenter and Chamberlain 1946)<sup>b</sup>

*Cx. peccator* Dyar and Knab (Carpenter and Chamberlain 1946)

*Cx. pilosus* (Dyar and Knab) (Carpenter and Chamberlain 1946)

*Cx. pipiens* L. (Wanamaker et al. 1944)<sup>a,b</sup>

*Cx. quinquefasciatus* Say (Carpenter and Chamberlain 1946)<sup>a,b</sup>

*Cx. restuans* Theobald (Carpenter and Chamberlain 1946)<sup>a,b</sup>

*Cx. salinarius* Coquillett (Carpenter and Chamberlain 1946)<sup>a,b</sup>

*Cx. tarsalis* Walker (Carpenter 1945)<sup>b</sup>

*Cx. territans* Coquillett (King et al. 1960)<sup>a,b</sup>

Genus *Culiseta* Felt

*Cs. inornata* (Williston) (Howard et al. 1912, 1915, 1917)<sup>a</sup>

*Cs. melanura* (Coquillett) (King et al. 1944)<sup>a</sup>

Genus *Orthopodomyia* Theobald

*Or. alba* Baker (Shields and Miles 1937)

*Or. signifera* (Coquillett) (Dyar 1928)<sup>a</sup>

## Checklist and Bibliography of the Mosquitoes

### (Table 1 continued)

#### Genus *Psorophora* Robineau-Desvoidy

- Ps. ciliata* (F.) (King et al. 1944)<sup>a,b</sup>  
*Ps. columbiae* (Dyar and Knab) (King et al. 1944 (as "*confinnis*")<sup>b</sup>  
*Ps. cyanescens* (Coquillett) (Shields 1938)<sup>a,b</sup>  
*Ps. discolor* (Coquillett) (Shields 1938)<sup>b</sup>  
*Ps. ferox* (von Humboldt) (Carpenter and Chamberlain 1946)<sup>a,b</sup>  
*Ps. horrida* (Dyar and Knab) (Carpenter and Chamberlain 1946)<sup>a,b</sup>  
*Ps. howardii* Coquillett (Shields 1938)<sup>a,b</sup>  
*Ps. mathesoni* Belkin and Heinemann (Shields 1938( as "*varipes*"))<sup>a,b</sup>

#### Genus *Uranotaenia* Lynch-Arribalzaga

- Ur. lowii* Theobald (King et al. 1943)  
*Ur. sapphirina* (Osten-Sacken) (King et al. 1944)<sup>a,b</sup>

#### Genus *Wyeomyia* Theobald

- Wy. haynei* Dodge (Dodge 1947)<sup>b</sup>

#### Subfamily Toxorhynchitinae

#### Genus *Toxorhynchites* Theobald

- Tx. rutilis septentrionalis* Dyar and Knab (Jenkins and Carpenter 1946)<sup>a,b</sup>
- 

<sup>a</sup>Voucher specimens in TVA Collection, Muscle Shoals, AL.

<sup>b</sup>Voucher specimens in Auburn University Entomology Collection.

LITERATURE CITED

- Anonymous. 1986. *Aedes albopictus* mosquito: A new dengue source. Alabama Department of Public Health. Communicable Dis. Rept. 8: 1.
- Anonymous. 1990. Tiger tales. Amer. Mosq. Control Assoc. Newsl. 16: 5-12.
- Bargren, W.C. 1951. Mosquitoes from the Third Army Area. Hq. Third Army, Ft. McPherson, GA 63 pp.
- Bargren, W.C. 1953. Mosquito larvae from the Third Army Area. Hq. Third Army, Ft. McPherson, GA 69 pp.
- Bargren, W.C. 1958. Mosquitoes from Lee County, Alabama. M.S. Thesis, Alabama Polytechnic Institute, Auburn, AL 169 pp.
- Barr, A.R. 1957. The distribution of *Culex p. pipiens* and *C. p. quinquefasciatus* in North America. Am. J. Trop. Med. Hyg. 6: 153-165.
- Belkin, J.N. and S.J. Heinemann. 1975. *Psorophora (Janthinosoma) mathesoni* sp. nov. for "varipes" of the southeastern USA. Mosq. Syst. 7:363-366.
- Belkin, J.N., S.J. Heinemann, and W.A. Page. 1970. Mosquito studies (Dipteria: Culicidae). XXI. The Culicidae of Jamaica. Contr. Am. Entomol. Inst. 6(1): 1-485.
- Bickley, W.E. 1976. The *Psorophora confinnis* complex. Mosq. News 36: 376.
- Bradley, G.H., R.F. Fritz, and L.E. Perry. 1944. Additional mosquito records for the southeastern states. J. Econ. Entomol. 37:109.
- Breeland, S.G., W.E. Snow, and E. Pickard. 1961. Mosquitoes of the Tennessee Valley. J. Tenn. Acad. Sci. 36:249-319.
- Carpenter, S.J. 1945. Collection records of *Culex tarsalis* in Army camps in the southeastern United States during 1942, 1943, and 1944. J. Econ. Entomol. 38: 404-406.
- Carpenter, S.J. and R.W. Chamberlain. 1946. Mosquito collections at Army installations in the Fourth Service Command, 1943. J. Econ. Entomol. 37:82-88.
- Carpenter, S.J., R.W. Chamberlain, and J.F. Wanamaker. 1945. New distribution records for mosquitoes of the southeastern United States in 1944. J. Econ. Entomol. 38: 401-402.



## Checklist and Bibliography of the Mosquitoes

- Carpenter, S.J. and W.W. Middlekauf. 1944. Inland records of salt marsh mosquitoes. *J. Econ. Entomol.* 37: 108.
- Carpenter, S.J., W.W. Middlekauf, and R.W. Chamberlain. 1946. The mosquitoes of the southeastern United States east of Oklahoma and Texas. *Am. Midl. Nat. Monogr. No. 3. Univ. Notre Dame.* 292 pp.
- Darsie, R.F., Jr. 1978. Additional changes in mosquito taxonomy in North America, north of Mexico, 1972-1977. *Mosq. Syst.* 10: 246-248.
- Darsie, R.F., Jr. and R. A. Ward. 1981. Identification and geographical distribution of the mosquitoes of North America, north of Mexico. *Mosq. Syst. Suppl.* 1: 1-313.
- Darsie, R.F., Jr. and R.A. Ward. 1989. Review of new Nearctic mosquito distributional records north of Mexico, with notes on additions and taxonomic changes of the fauna, 1982-89. *J. Am. Mosq. Control Assoc.* 5: 552-557.
- Darsie, R.F., Jr. and R.M. Williams. 1976. First report of *Wyeomyia haynei* in Georgia, with comments on identification of larvae (Diptera: Culicidae). *Mosq. Syst.* 8: 441-444.
- Dodge, H.R. 1947. A new species of *Wyeomyia* from the pitcher plant. *Proc. Entomol. Soc. Wash.* 49: 117-122.
- Dyar, H.G. 1923. The mosquitoes of the United States. *U.S. Natl. Mus. Proc.* 62(2): 1-119.
- Dyar, H.G. 1928. The Mosquitoes of North America. *Carnegie Inst. Wash. Publ.* No. 387. 616 pp.
- Floore, T.G., B.A. Harrison, and B.F. Eldridge. 1976. The *Anopheles* (*Anopheles*) *crucians* subgroup in the United States (Diptera: Culicidae). *Mosq. Syst.* 8: 1-109.
- Griffitts, T.H.D. 1927. *Anopheles atropos* Dyar and Knab, a note on its breeding and other habits. *U.S. Publ. Health Repts.* 42: 1903-1905.
- Guyton, F.E. 1935. Pest mosquito control in Alabama under C.W.A. *J. Econ. Entomol.* 28: 786-790.
- Howard, L.O., H.G. Dyar, and F. Knab. 1912, 1915, 1917. The Mosquitoes of North and Central America and the West Indies. *Carnegie Inst. Wash. Publ. No. 159*, 4 vols.

- Jenkins, D.W. 1949. *Toxorhynchites* mosquitoes of the United States. Proc. Entomol. Soc. Wash. 51: 225-229.
- Jenkins, D.W. and S.J. Carpenter. 1946. Ecology of the treehole breeding mosquitoes of Nearctic North America. Ecol. Monogr. 16: 33-48.
- Johnson, W.E., Jr. and L. Harrell. 1980. The occurrence of *Aedes trivittatus* in Alabama. Mosq. News 40: 296-297.
- Kaiser, P.E., S.E. Mitchell, G.C. Lanzaro, and J.A. Seawright. 1988. Hybridization of laboratory strains of sibling species A and B of *Anopheles quadrimaculatus* Say J. Am. Mosq. Control Assoc. 3: 222-230.
- King, W.V. and G.H. Bradley. 1941. Distribution of Nearctic species of *Anopheles*. Am. Assoc. Adv. Sci. Publ. No. 15: 71-78.
- King, W.V., G.H. Bradley, and T.E. McNeel. 1944. The mosquitoes of the southeastern United States. USDA Misc. Publ. No. 336, 96 pp.
- King, W.V., G.H. Bradley, C.N. Smith, and W.C. McDuffie. 1960. A handbook of the mosquitoes of the southeastern United States. USDA Agr. Handbk. No. 173, 188 pp.
- King, W.V., L. Roth, J. Toffaleti, and W.W. Middlekauf. 1943. New distribution records for the mosquitoes of the southeastern United States during 1942. J. Econ. Entomol. 36: 573-577.
- Knight, K.L. and A. Stone. 1977. A Catalog of the Mosquitoes of the World. Thomas Say Foundation Monogr. No. 6, 611 pp.
- Lanzaro, G.C., S.K. Narang, S.E. Mitchell, P.E. Kaiser, and J.A. Seawright. 1988. Hybrid male sterility in crosses between field and laboratory strains of *Anopheles quadrimaculatus*. J. Med. Entomol. 25: 248-255.
- Lanzaro, G.C., S.K. Narang, J.A. Seawright. 1990. Speciation in an anopheline (Dipteria: Culicidae) mosquito: enzyme polymorphism and the genetic structure of populations. Ann. Entomol. Soc. Am. 83: 578-585.
- Michener, C.D. 1945. Seasonal variations in certain species of mosquitoes (Dipteria: Culicidae). J. New York Entomol. Soc. 53: 293-300.
- Middlekauf, W.W. and S.J. Carpenter. 1944. New distribution records for the mosquitoes of the southeastern United States in 1943. J. Econ. Entomol. 37: 88-92.

## Checklist and Bibliography of the Mosquitoes

- Miles, V.I. and S.O. Hill. 1948. Distribution of mosquitoes in the Third Army Area. Hq. Third Army, Ft. McPherson, GA. 69 pp.
- Miles, V.I. and R.W. Rings. 1946. Distribution records for mosquitoes of the southeastern states in 1945. J. Econ. Entomol. 39: 387-391.
- Mullen, G.R. and L.J. Hribar. 1988. Mosquito-borne diseases in Alabama. Ala. J. Med. Sci. 25: 268-273.
- Narang, S.K., P.E. Kaiser, and J.A. Seawright. 1989. Dichotomous electrophoretic taxonomic key for identification of sibling species A, B, and C of the *Anopheles quadrimaculatus* complex (Diptera: Culicidae). J. Med. Entomol. 26: 94-99.
- O'Meara, G.F. and G.B. Craig, Jr. 1970. Geographical variation in *Aedes atropalpus* (Diptera: Culicidae). Ann. Entomol. Soc. Am. 63: 1392-1400.
- Pratt, H.D. 1945. *Mansonia indubitans* Dyar and Shannon - a new mosquito addition to the United States fauna. J. Kans. Entomol. Soc. 18: 121-129.
- Pratt, H.D. 1953. Notes on American *Mansonia* mosquitoes (Diptera: Culicidae). Proc. Entomol. Soc. Wash. 55: 9-19.
- Reinert, J.F. 1975. Mosquito generic and subgeneric abbreviations (Diptera: Culicidae). Mosq. Syst. 7: 105-110.
- Rings, R.W. and S.O. Hill. 1948. The taxonomic status of *Aedes mathesoni* (Diptera: Culicidae). Proc. Entomol. Soc. Wash. 50: 41-49.
- Russell, P.F. 1925. Identification of larvae of the three common anopheline mosquitoes of the southern United States. Am. J. Hyg. 5: 149-174.
- Shields, S.E. 1938. Tennessee Valley mosquito collections. J. Econ. Entomol. 31: 426-430.
- Shields, S.E. and J.B. Lackey. 1938. Conditions affecting mosquito breeding with special reference to *Aedes thibaulti* Dyar and Knab (Diptera: Culicidae). J. Econ. Entomol. 31: 95-102.
- Shields, S.E. and V.I. Miles. 1937. The occurrence of *Orthopodomyia alba* in Alabama (Diptera: Culicidae). Proc. Entomol. Soc. Wash. 39: 237.
- Snow, W.E. 1949. Studies on portable resting stations for *Anopheles quadrimaculatus* in the Tennessee Valley. J. Nat. Malaria Soc. 8: 336-343.



- Snow, W.E. 1951. A preliminary review of the mosquitoes of the Tennessee Valley region. Unpublished TVA report. Div. Health and Safety, Tennessee Valley Authority, Wilson Dam, AL. 283 pp. + 46 maps.
- Snow, W.E. and E. Pickard. 1956. Seasonal history of *Culex tarsalis* and associated species in larval habitats of the Tennessee Valley region. Mosq. News 16: 143-148.
- Snow, W.E. and G.E. Smith. 1956. Observations on *Anopheles walkeri* Theobald in the Tennessee Valley. Mosq. News 16: 294-298.
- Stojanovich, C.J. 1960. Illustrated key to common mosquitoes of the southeastern United States. CDC, Atlanta, GA. 36 pp.
- Wanamaker, J.F., R.W. Chamberlain, and S.J. Carpenter. 1944. Distribution of *Culex pipiens* in the southeastern United States. J. Econ. Entomol. 37: 106-107.
- Watson, R.B. and E.L. Spain, Jr. 1937. Studies on malaria in the Tennessee Valley. The influence of physiography on the occurrence of breeding places of *Anopheles quadrimaculatus* in northern Alabama. Am. J. Trop. Med. 17: 289-305.
- Zavortink, T.J. 1972. Mosquito studies (Diptera, Culicidae) XXVIII. The New World species formerly placed in *Aedes* (*Finlaya*). Contr. Am. Entomol. Inst. 8(3): 1-206.

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**COVER PHOTOGRAPHS:** Specimens of the blue crabs *Callinectes sapidus* (top) and *Callinectes similis* (bottom). These common crabs are distinguished on the basis of maximum body size, chelae coloration and frontal teeth along the anterior edge of the carapace. Both species co-occur in Mobile Bay, Alabama in large numbers. The distribution of *Callinectes similis* appears to be regulated in part by salinity and congeneric predation by *C. sapidus* (see paper this volume). Photographs courtesy of Pan-Wen Hsueh.

Pan-Wen Hsueh is a doctoral candidate in the Department of Biology at the University of Alabama at Birmingham. His research interest include the larval ecology and population biology of crustaceans.



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## A LETTER FROM THE EDITOR

Dear Members of the Alabama Academy of Science:

If *The Journal* is to continue to be published quarterly and if it is to maintain the quality that it now enjoys, the rate of submission of articles for publication must increase dramatically. This is therefore a call to the members of all Sections of The Academy to support *The Journal* by submitting high quality research or review articles for publication.

Recent visits with several Academy members and officers have encouraged me to especially solicit timely, concise review articles from all disciplines. Beginning with the next issue, I would like to publish two review articles per issue. I and those with whom I have spoken believe that the regular publication of short, critical reviews would enhance the value of *The Journal* to the membership and provide an opportunity for many of us to develop that area of our scholarship. I look forward to receiving your manuscripts and would welcome any suggestions you have for *The Journal*.

Sincerely,

A handwritten signature in cursive script, reading "J. T. Bradley". The signature is written in dark ink and is positioned above the printed name.

James T. Bradley, Editor

*Journal of the Alabama Academy of Science*

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FACTORS AFFECTING THE POPULATION DYNAMICS OF THE LESSER  
BLUE CRAB (*CALLINECTES SIMILIS* WILLIAMS) IN BARRIER  
ISLAND SALT MARSH HABITATS OF THE GULF OF MEXICO<sup>1</sup>

Pan-Wen Hsueh and James B. McClintock  
Department of Biology  
University of Alabama at Birmingham  
Birmingham, AL 35294

and

Thomas S. Hopkins  
University of Alabama, Tuscaloosa  
and  
Marine Environmental Sciences Consortium  
Dauphin Island, AL 36528

ABSTRACT

Although adults of the lesser blue crab *Callinectes similis* are found abundantly in high salinity mid-bay waters, juveniles (<40 mm CW) occur in abundance in barrier island salt marsh habitats of Mobile Bay, Alabama, during seasons of low freshwater influx. We have investigated factors which may regulate this pattern of distribution and abundance. Laboratory experiments exposing lesser blue crabs to 5, 10, 15, 20, 25 and 30 ppt demonstrated that juvenile and adult *C. similis* suffered 75% mortality at 5 ppt over a period of 7 days. We suggest that limited osmoregulatory ability may be one important factor which restricts juvenile lesser blue crabs from marsh habitats during extended periods of low salinity. Field caging experiments were conducted to investigate congeneric and conspecific patterns of predation in *C. similis* and *C. sapidus*. Both species were cannibalistic and adult *C. sapidus* prey heavily on juvenile *C. similis*. Therefore, *C. sapidus* may have a potential predatory role in regulating the abundance of juvenile *C. similis* in barrier island salt marsh habitats along the northern Gulf of Mexico.

INTRODUCTION

The lesser blue crab, *Callinectes similis* Williams, is widely distributed with its congener, *Callinectes sapidus* Rathbun, in estuaries along the northern Gulf of Mexico (Perry, 1984). Nonetheless, habitat partitioning is reported to occur in these two blue crabs. *Callinectes similis* apparently prefers bay and offshore high-salinity waters, whereas *C. sapidus* dominates numerically in low-salinity estuaries and bays (Perry,

<sup>1</sup>Manuscript received 29 January 1992; accepted 5 February 1992.

1984; Williams, 1984; Hsueh, 1992). This generally partitioned distribution is thought to be related in part to the inability of *C. similis* to tolerate low salinity. Engel (1977) examined ion concentrations in the hemolymph of these species, and found that at 5 ppt salinity, adult *C. sapidus* are superior hypo-osmoregulators in comparison to adult *C. similis*. No difference in osmoregulatory ability was reported at high salinities in these species.

In Mobile Bay, Alabama, juvenile *C. similis* co-occur with all age classes of *C. sapidus* in barrier island salt marsh habitats during late spring, summer and fall when salinities are 8-28 ppt (Hsueh, 1992). However, juvenile *C. similis* were not observed in marsh habitats during winter and early spring when salinities periodically fell to 5 ppt or less. Moreover, adult *C. similis* were never observed in barrier island marsh habitats regardless of season or salinity (Hsueh, 1992). Although seasonal patterns of juvenile *C. similis* in salt marsh habitats may be determined in part by salinity levels, it is likely that congeneric predation could be an important factor in regulating both juvenile and adult patterns of abundance. *Callinectes sapidus* is an aggressive predator which is cannibalistic and capable of preying upon other species of brachyurans (Hines *et al.*, 1990; Mansour and Lipcius, 1991). Although *C. similis* and *C. sapidus* co-occur in some habitats, there is no information available on their predator/prey interactions.

The present study examines the question: "Do reduced salinity and congeneric predation contribute to the limited distribution of juvenile and adult *C. similis* in barrier island salt marsh habitats containing abundant *C. sapidus*?" Furthermore, this study extends the evaluation of cannibalism in blue crabs to *C. similis*, an extremely abundant yet little studied species.

## MATERIAL AND METHODS

Blue crabs were collected during the summer of 1990 in Mobile Bay, Alabama. Lesser blue crabs (*Callinectes similis*) were collected from a site near channel marker #28 and *C. sapidus* from the Dauphin Island Airport Marsh. Crabs were not fed to standardize nutritive condition, and they were used for salinity and predation experiments within one and three days of their collection, respectively. The salinity tolerance of *C. sapidus* is well known (Tagatz, 1971; Engel, 1977). Therefore, we chose to examine only *C. similis*. Juveniles (20-30 mm carapace width, CW) and adults (> 70 mm CW) were collected by trawling. Ambient salinities at the sampling sites ranged from 26 to 28 ppt at the time of collection. Crabs were maintained in 20 ppt seawater in a recirculating tank for 24 hrs, and only healthy undamaged crabs were used in experiments.

### Salinity tolerance

Partitioned aquaria (90 x 60 x 20 cm) containing 5, 10, 15, 20, 25, or 30 ppt artificial seawater (Tropic Marin) were used. Each aquarium held 12 crabs in 20 x

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20 cm compartments. Juvenile ( $n=12$ ) or adult ( $n=12$ ) *C. similis* were transferred to each aquarium, and mortality in each salinity treatment was monitored over a 7-day period. Crabs were exposed to each salinity without acclimation. No food was provided for the crabs during the 7-day experimental period. Preliminary observations indicated that non-fed crabs remain robust for at least two weeks. Salinity tolerance experiments for both juvenile and adult crabs were replicated once. A contingency table analysis was used to compare differences in mortality among juvenile and adult *C. similis* exposed to various salinity treatments (Sokal and Rohlf, 1981).

### Congeneric predation and cannibalism

Different combinations of sizes and densities of both *C. similis* and *C. sapidus* were deployed in rectangular 1-cm mesh cages measuring 100 x 50 x 20 cm (L x W x H). The corners of each cage were secured to the bottom using 2-cm diameter PVC pipes. The bottom of the cage was submerged approximately 5 cm into the soft sediment in order to provide crabs an opportunity to seek refuge by burrowing. Crab densities used in each cage were determined on the basis of crab size. Densities were similar to those used in a density-dependent foraging study by Mansour and Lipcius (1991) for *C. sapidus* in Chesapeake Bay. These values are considered to be equivalent to moderate to high field densities. Each deployment was replicated three times except for the small *C. sapidus*/small *C. similis* treatment which could only be conducted once due to the limited availability of crabs in this size class. Cages were deployed next to the Dauphin Island Sea Laboratory boat dock at a depth of 1 m. After 24 hrs, the numbers and sizes of surviving crabs were recorded. Evidence of congeneric predation or cannibalism was documented by counting the remains (usually the carapace) of individual crabs. Mortality rates were statistically compared between different size combinations of crabs using a contingency table analysis.

## RESULTS

### Salinity tolerance

Both juvenile and adult *C. similis* exposed to 5 ppt salinity showed 13 and 21% mortality, respectively, after day one of the experiment (Fig. 1). There was a sharp increase in adult mortality (linear regression, slope = 50) and a gradual increase in juvenile mortality (slope = 4.1) at 5 ppt by day 6 of the experiment. By day seven, 75% mortality had occurred in both juvenile and adult crabs exposed to 5 ppt. Juvenile and adult crabs exposed to 5 ppt salinity had significantly greater cumulative mortality than all other salinity treatments. Mortality estimates of juvenile crabs in the 15 ppt salinity treatment were confounded by anthropogenic contamination of the sea water and were not included in the analyses. Mortalities of adult crabs in the 10 and 15 ppt salinity treatments were significantly greater than in the 20, 25, and 30 ppt salinity treatment ( $P < 0.05$ ) (Fig. 1). Except for the 20 ppt salinity treatment, there were not significant differences in mortality between juvenile and adult crabs at each salinity treatment ( $P > 0.05$ ).



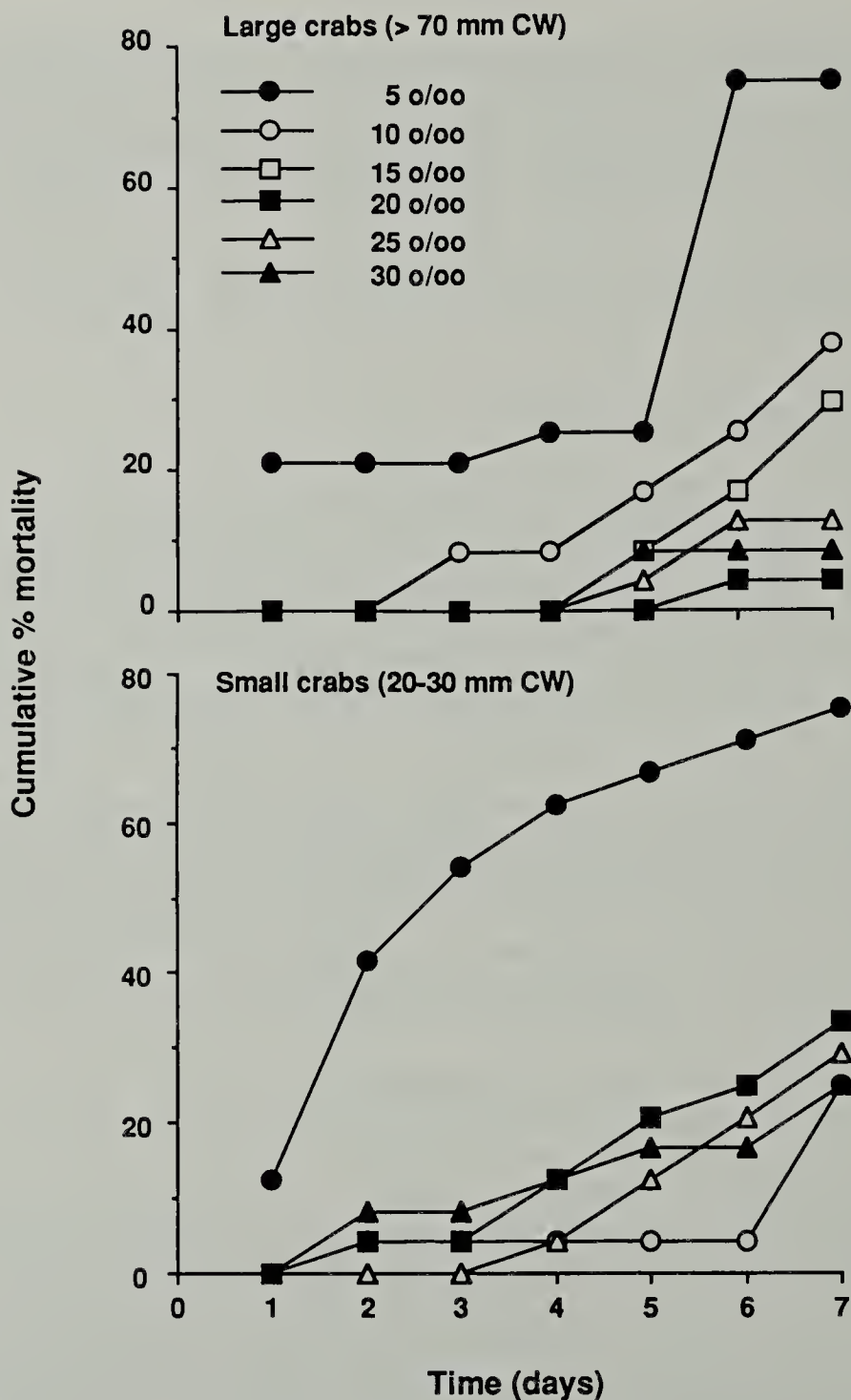


Figure 1. Cumulative daily percent mortality of small (20-30 mm CW) and large (> 70 mm CW) *Callinectes similis* after acute exposure to 5, 10, 15, 20, 25, and 30 ppt. Data for juvenile crabs held at 15 ppt are not presented (see text).

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### Congeneric predation and cannibalism

Both congeneric predation and cannibalism were observed in *Callinectes similis* and *C. sapidus*. Larger *C. sapidus* had a significantly greater ( $P < 0.05$ ) predatory impact than smaller *C. sapidus* on small *C. similis* (Table 1). Congeneric predation on *C. similis* by large *C. sapidus* was significantly reduced ( $P < 0.05$ ) when *C. similis* sizes were increased from the 41-50 and 51-60 size classes to 91-100 mm CW (Table 1). Mortality of *C. sapidus* was minimal (0 to 14.3%) when caged with *C. similis* and in the larger size classes may have resulted from cannibalism (Table 1). Large *C. similis* had a relatively minor impact on small conspecifics. Small *C. similis* suffered only 23% ( $\pm 11$ ) mortality when kept in cages with large *C. similis*. There was no mortality of large *C. sapidus* or *C. similis* when caged with smaller conspecifics.

		<i>Callinectes sapidus</i>			
		51-60	71-80	91-100	> 120 (mm CW)
<i>Callinectes similis</i>	41-50	<div style="text-align: center;">14.3 — 0</div>	—	<div style="text-align: center;">13.3<math>\pm</math>13.3 — 43.3<math>\pm</math>7.7</div>	<div style="text-align: center;">11.1<math>\pm</math>11.1 — 80.0<math>\pm</math>8.8</div>
	51-60	—	<div style="text-align: center;">0 — 28.6<math>\pm</math>4.8</div>	—	<div style="text-align: center;">0 — 80.9<math>\pm</math>7.3</div>
	91-100 (mm CW)	—	—	—	<div style="text-align: center;">0 — 33.3<math>\pm</math>3.9</div>

Table 1. Mean % mortality ( $\pm 1$  SE) of *Callinectes similis* (lower numbers) and *C. sapidus* (upper numbers) placed in experimental cages. Short bars indicate experiments were not conducted with these size class combinations.

## DISCUSSION

It is well known that salinity is an important factor in regulating the distribution of a variety of marine invertebrates (Pearse and Gunter, 1957; Teal, 1958;

Gilles and Pequeux, 1983). Based on the lesser ability of *C. similis* to osmoregulate in low salinity (5 ppt) sea water, when compared to *C. sapidus*, Engel (1977) suggested that the distribution of *C. similis* should be limited to offshore waters where salinities range from 20 to 35 ppt. The present study provides direct evidence that *C. similis* is incapable of tolerating acute exposure to low salinities ( $\leq 5$  ppt) over a period of seven days. Nonetheless, *C. similis* appears to be able to tolerate moderate salinities (10-15 ppt). These laboratory studies correspond with field observations on the distribution of *C. similis*. Hsueh (1992) noted that numerous juvenile *C. similis* were found in shallow estuarine waters (e.g. Dauphin Island Airport Marsh and Mississippi Sound) where salinities ranged from 8-28 ppt during seasons of low freshwater influx. Consequently, we suggest that salinity may only become an important factor in regulating the distribution of *C. similis* when it falls to 5 ppt or less.

Although no differences in salinity tolerance were found between juvenile and adult *C. similis*, adult *C. similis* do not occur in shallow estuarine waters (Hsueh, 1992). This may be the result of continuous attrition of juveniles due to osmotic stress and mortality. It appears that only juvenile *C. similis* utilize shallow waters perhaps because vegetation provides structural refuge from predators and a potential nutrient source for juvenile blue crabs as seen in *C. sapidus* (Wilson *et al.*, 1987; Orth and van Montfrans, 1990; McClintock *et al.*, 1991).

In addition to low salinity, predation may be an important factor in regulating the distribution and abundance of *C. similis*. This factor has been shown to be an important determinant of population dynamics of marine invertebrates (Connell, 1961; Reise, 1977; Virnstein, 1977; Jensen and Jensen, 1985; Kennish, 1990). One apparent predator of *C. similis* in shallow marsh habitats is its congener, *C. sapidus*, which is abundant in these habitats (Churchill, 1919; Tagatz, 1968; Ettinger and Blye, 1981; Williams, 1984). *Callinectes sapidus* attains a larger body size than *C. similis* (19 vs 12 cm CW). Willason (1981) noted that the larger lined shore crab, *Pachygrapsus crassipes*, preys upon the smaller yellow shore crab, *Hemigrapsus oregonensis*, and limits its upper vertical distribution in salt marshes on the west coast of the United States. *Callinectes sapidus* is a top predator in benthic communities (Hines *et al.*, 1990). Crab remains, including conspecifics, are frequently found in the gut contents of *C. sapidus* (Laughlin, 1982; Hines *et al.*, 1990; Hsueh, 1992). Mansour and Lipcius (1991) noted the aggressive behavior of blue crabs may result in mortality of conspecifics when individuals are held in aquariums. The results of the field caging experiments indicate that adult *C. sapidus* can prey on juvenile *C. similis*. As in any caging experiment, predation effects may be somewhat inflated. Nonetheless, blue crabs were held at reasonable densities and were provided with a refuge (i.e., burial in sediments, *sensu* Orth and van Montfrans, 1982). It is likely that congeneric predation is a factor which influences the abundance of *C. similis* in shallow marsh habitats of Dauphin Island.



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Cannibalism in *Callinectes similis* is documented in this study for the first time. However, cannibalism does not appear to be as prevalent as is found in *C. sapidus* (Hines *et al.*, 1990; Mansour and Lipcius, 1991). Crab remains accounted for only 5% of the total prey consumed by *C. similis*, whereas this figure was 13% in *C. sapidus* (Hsueh, 1992). A reduced level of cannibalistic behavior in *C. similis* may facilitate the dense aggregation of all age classes of *C. similis* in open-bay habitats. Moreover, aggregation of *C. similis* in open-bay habitats may be a response to intense predation by *C. sapidus* in shallow marsh habitats. Few *C. sapidus* co-occur with *C. similis* in open-bay habitats of Mobile Bay (Hsueh, 1992).

In summary, we suggest that the population dynamics of *C. similis* in shallow salt marsh habitats of Mobile Bay, Alabama, may be influenced by both salinity and congeneric predation. During the seasons of abundant freshwater influx into the Mobile Bay estuarine system (winter and early spring), *C. similis* may be forced out of shallow marsh habitats due to its inability to osmoregulate effectively. However, pulses of megalopae and juveniles of *C. similis* recruit into shallow marsh habitats during late spring, summer and fall, when salinities in these habitats are higher (Hsueh, 1992; K. Heck, pers. comm.). As juvenile *C. similis* grow, their numbers may be reduced in shallow marsh habitats as a result of predation by *C. sapidus*.

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## LITERATURE CITED

- Churchill, E. P., Jr. 1919. Life history of the blue crab. US Bull. Bureau Fish. 36 (for 1917-1918): 95-128.
- Connell, J. H. 1961. Effects of competition, predation by *Thais lapillus*, and other factors on natural populations of the barnacle *Balanus balanoides*. Ecol. Monogr. 31: 61-104.

- Engel, D. W. 1977. Comparison of the osmoregulatory capabilities of two portunid crabs, *Callinectes sapidus* and *C. similis*. Mar. Biol. 41: 275-279.
- Ettinger, W. S., and R. W. Blye, Jr. 1981. Occurrence of the blue crab *Callinectes sapidus* in the tidal freshwater reaches of the Delaware and Schuylkill Rivers in 1976. J. Crust. Biol. 1: 177-182.
- Gilles, R. and A. Pequeux. 1983. Interactions of chemical and osmotic regulation with the environment. In F. J. Vernberg and W. B. Vernberg. eds. The biology of Crustacea (Volume 8): environmental adaptations. Pp. 109-165. Academic Press, Inc., New York. 383 Pp.
- Hines, A. H., A. M. Haddon, and L. A. Wiechert. 1990. Guild structure and foraging impact of blue crabs and epibenthic fish in a subestuary of Chesapeake Bay. Mar. Ecol. Prog. Ser. 67: 105-126.
- Hsueh, P. 1992. A comparative study of the population dynamics, life history characteristics and physiological ecology of *Callinectes similis* and *C. sapidus* in estuarine environments of the Northern Gulf of Mexico. Ph.D. Dissertation, University of Alabama at Birmingham.
- Jensen, K. T., and J. N. Jensen. 1985. The importance of some epibenthic predators on the density of juvenile benthic macrofauna in the Danish Wadden Sea. J. Exp. Mar. Biol. Ecol. 89: 157-174.
- Kennish, M. J. 1990. Ecology of estuaries (Volume II): biological aspects. Pp. 250-251. CRC Press, Boca Raton, Florida. 391 Pp.
- Laughlin, R. A. 1982. Feeding habits of the blue crab, *Callinectes sapidus* Rathbun, in the Apalachicola estuary, Florida. Bull. Mar. Sci. 32: 807-822.
- Mansour, R. A., and R. N. Lipcius. 1991. Density-dependent foraging and mutual interference in blue crabs preying upon infaunal clams. Mar. Ecol. Prog. Ser. 72: 239-246.
- McClintock, J. B., T. S. Klinger, K. Marion, and P. Hsueh. 1991. Digestive carbohydrases of the blue crab *Callinectes sapidus*: implications in utilization of plant-derived detritus as a trophic resource. J. Exp. Mar. Biol. Ecol. 148: 233-239.
- Orth, R. J., and J. van Montfrans. 1982. Predator-prey interactions in an eelgrass ecosystem in the lower Chesapeake Bay. In R. J. Orth and J. van Montfrans (eds.), Structure and functional aspects of the biology of submerged aquatic macrophyte communities in the lower Chesapeake Bay. Volume III, Pp 81-94. VIMS-SRAMSOE 267.

## Factors affecting the lesser blue crab

- , 1990. Utilization of marsh and seagrass habitats by early stages of *Callinectes sapidus*: a latitudinal perspective. *Bull. Mar. Sci.* 46: 126-144.
- Pearse, A. S., and G. Gunter. 1957. Salinity. In J. W. Hedgpeth ed. *Treatise on marine ecology and paleoecology* (Volume I): Ecology. Pp. 129-158. The geological Society of America, Memoir No. 67. 1296 Pp.
- Perry, H. M. 1984. A profile of the blue crab fishery of the Gulf of Mexico. Gulf States Marine Fisheries Commission, Ocean Spring, Mississippi. Vol. 9. 80 Pp.
- Reise, K. 1977. Predator exclusion experiments in an intertidal mud flat. *Helgol. Wiss. Meeresunters.* 30: 263-271.
- Sokal, R. R., and F. J. Rohlf. 1981. *Biometry*. W. H. Freeman and Company, San Francisco. 859 Pp.
- Tagatz, M. E. 1968. Biology of the blue crab, *Callinectes sapidus* Rathbun, in the St. John River, Florida. *Fish. Bull.* 67: 17-23.
- , 1971. Osmoregulatory ability of blue crabs in different temperature-salinity combinations. *Chesapeake Sci.* 12: 14-17.
- Teal, J. M. 1958. Distribution of fiddler crabs in Georgia salt marshes. *Ecology* 39: 185-193.
- Virnstien, R. W. 1977. The importance of predation by crabs and fishes on benthic infauna in Chesapeake Bay. *Ecology* 58: 1199-1217.
- Willason, S. W. 1981. Factors influencing the distribution and coexistence of *Pachygrapsus crassipes* and *Hemigrapsus oregonensis* (Decapoda: Grapsidae) in a California salt marsh. *Mar. Biol.* 64: 125-133.
- Williams, A. B. 1984. Shrimps, lobsters, and crabs of the Atlantic coast of the eastern United States, Marine to Florida. Smithsonian Institution press, Washington, D. C. 550 pp.
- Wilson, K. A., K. L. Heck, Jr., and K. W. Able. 1987. Juvenile blue crab, *Callinectes sapidus*, survival: an evaluation of eelgrass, *Zostera marina*, as refuge. *Fish. Bull.* 85: 53-57.



EFFECTS OF PHOTOPERIOD ON STRIPED BASS (*MORONE SAXATILIS*)  
LARVAE AND STRIPED BASS X WHITE BASS HYBRID  
(*M. SAXATILIS* X *M. CHRYSOPS*) LARVAE  
IN AN INTENSIVE CULTURE SYSTEM<sup>1</sup>

Malcolm R. Braid  
Department of Biology  
University of Montevallo  
Montevallo, AL 35115

ABSTRACT

Two short-term trials were conducted in an intensive culture system on the effects of photoperiod on survival, cannibalism, growth, and behavior of striped bass (*Morone saxatilis*) larvae and striped bass x white bass hybrid (*M. saxatilis* X *M. chrysops*) larvae. Photoperiod was not found to significantly affect survival or cannibalism of either striped bass or hybrid larvae. Photoperiod of 0 h resulted in significantly less growth of striped bass than other photoperiods. Better survival of hybrid larvae compared to striped bass larvae may be due to a combination of more tolerance to handling and faster growth, but not due to less cannibalism. Hybrid larvae exhibited significantly faster growth than striped bass larvae which was unrelated to photoperiod. Behavioral response of larvae to sudden light exposure included a brief period of agitation and adjustment, then sometimes attraction to the light at the expense of feeding. Hybrid larvae seemed to be less strongly influenced by sudden illumination than were striped bass larvae.

INTRODUCTION

While the effects of many factors on the survival and growth of striped bass (*Morone saxatilis*) larvae and striped bass x white bass hybrid (*Morone saxatilis* female x *M. chrysops* male) larvae have been investigated, very little research has concerned effects of photoperiod. Varied effects of light during culture of other fish species have been well documented. Channel catfish (*Ictalurus punctatus*) fry grew better under a 14-h photoperiod than under a 10-h one, and experienced non-significantly higher survival (Kilambi et al., 1970). Green sunfish (*Lepomis cyanellus*) ate more, grew faster, and had higher food conversion efficiency under longer periods of light than during shorter ones (Gross et al., 1965). Sea bass (*Dicentrarchus labrax*) larvae experienced higher mortality when exposed to continuous light or to increased light intensity at elevated temperature, although growth was unaffected (Johnson and Katavic, 1984).

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Reduction of water clarity by shading, dyes, or turbidity resulted in higher survival of striped bass hybrid larvae in aquaria and ponds (Rees and Cook, 1982). It was not known if the benefits of decreased light were due to reduced exposure to ultraviolet radiation or cannibalism, or other factors. Cannibalism has been shown to be an important cause of fish loss during striped bass larvae culture (Braid and Shell, 1981); relationship between photoperiod and extent of cannibalism is not known for such fish. At night, largemouth bass (*Micropterus salmoides*) fry are thought to cease feeding and to rest on the bottom with a lower metabolic rate (Laurence, 1971). Whether such a period of inactivity during darkness improves the growth rate of *Morone* larvae is unknown.

Such evidence would indicate that photoperiod may be of importance during the culture of striped bass and hybrid larvae. Although the consequences are not known, room lights are typically left on constantly in most striped bass hatcheries during the production season. Since best survival may result when larvae are held indoors to 15 days of age before stocking into ponds (Bonn et al., 1976), the studies described in this paper were of similar duration. Hybrid larvae were included in one trial since increasing numbers of them are being produced due to their reported better survival and growth when compared with striped bass (Bishop, 1967; Logan, 1967). Therefore, objectives of this research were to determine: 1) if an optimum photoperiod exists for best growth of larvae due to conservation of energy, 2) if an optimum photoperiod exists for best survival by limiting losses due to cannibalism, 3) whether there are differences in effects of photoperiod on survival and growth of striped bass larvae compared to hybrid larvae, and 4) what effect photoperiod may have on behavior of striped bass and hybrid larvae.

## MATERIALS AND METHODS

A recirculating water system was used in which a 456-L plastic wading pool with a double plastic liner served as a water reservoir. Each of two submersible pumps sent water of 10 o/oo salinity up into an overhead water distributing device, from which latex water lines with flow valves and glass tubing at the end supplied 3.8-L glass fish-holding jars. The jars were arranged linearly along the two sides of a wooden table built over the reservoir pool. Water exited from the jars through prime-retaining siphons (Braid, 1987), flowed down a trough into activated charcoal filters containing floss and marine gravel, and trickled back into the pool. Flow rate through each jar was 100 mL/min. The window was covered with black polyethylene to eliminate sunlight, and the room lights (eight 40-W Sylvania fluorescent bulbs) remained on constantly.

In each of two experiments, photoperiod was regulated by enclosing each jar in a black polyethylene bag to restrict light. When larvae were to be exposed to light, these bags were pulled down around the bottom of the jars. When darkness was desired, the bags were pulled up above the tops of the jars and secured with

## Effects of photoperiod on striped bass

clothespins. Photoperiods (hours light/hours dark) tested in experiment 1 were 24L/OD, 18L/6D (light from 0600-2400h), 12L/12D (light from 0600-1800h), 6L/18D (light from 0900-1500h), and 0L/24D, with three replications of each. In experiment 2, photoperiods were 24L/OD and 12L/12D (light from 0600-1800h), with three replications of each. While the bags around jars in the 24L/OD treatment were never pulled up, they provided the same background during feeding as in the other jars. These photoperiod designations do not include periods of light exposure when the bags were lowered prior to and during each feeding. Larvae were allowed at least 5 min to adjust to room light before feeding, and 15 min to feed before bags were pulled up. Periods of light and darkness were planned to coincide with times of natural daylight and darkness. Jars were randomly selected to receive specific photoperiod treatments.

In experiment 1, 2-day-old Coosa River striped bass prolarvae from Marion Fish Hatchery, AL, were held in holding jars until stocking into test jars at 3 days of age. Stocking involved dipping prolarvae from holding jars, then using white plastic spoons to count and transfer small numbers of prolarvae into plastic cups. When 150 prolarvae were counted, they were stocked according to a random stocking sequence. Each jar was stocked twice, yielding 300 prolarvae per jar. Those that died were removed and replaced by 5 days of age, and feeding and photoperiod treatments were begun at 6 days of age.

In experiment 2, 5-day-old Coosa River striped bass larvae and hybrid larvae were transferred in water of 10 o/oo salinity from Marion Fish Hatchery and stocked directly into separate test jars. Three replicate jars of each of the two fish types for each photoperiod were randomly arranged. A randomized stocking procedure similar to that described for experiment 1 was used, except that each jar was stocked once with 300 larvae. Feeding and photoperiod treatments began later this day. Dead larvae were removed and replaced the next day, when the experiment began.

During both experiments, larvae were hand-fed live brine shrimp (*Artemia* spp.) nauplii at intervals of 3 h, in amounts to insure that adequate food was available for all larvae. Water temperature and pH were monitored. After completion of the experiments, 20 larvae from each jar in experiment 1 and 30 larvae from each jar in experiment 2 were measured for total length using dial calipers.

Dead larvae were removed from each jar and counted daily. Residue containing dead larvae was siphoned from each jar into a 1-L beaker, then poured into Petri dishes. Using a large 5X hand lens, larvae were counted over dark and light backgrounds to observe opaque and transparent individuals. Those which died and those which survived were subtracted from the initial number of larvae stocked to yield the number of missing larvae. It was assumed that these larvae were missing due to cannibalism. For experiment 1 data, significance of treatment differences among photoperiods for striped bass survival, cannibalism, and growth was tested using Duncan's multiple range test (Steel and Torrie, 1960; protection level = 0.05).



For experiment 2 data, significance of treatment differences between photoperiods for striped bass and hybrid survival, cannibalism, growth, and larval type was analyzed using two-way analysis of variance (Steel and Torrie, 1960;  $P=0.05, 0.01$ ).

## RESULTS AND DISCUSSION

*Experiment 1.* After 12 days of culture, average survival for all jars was 55.7%. No significant differences in survival or mortality were found (Table 1). Some larger larvae, some of which contained brine shrimp in the gut, died by 10 days of age. The smallest live larvae usually contained few or no brine shrimp. Sometimes larvae closely inspected brine shrimp nauplii, but failed to consume them for no apparent reason. Whether these larvae later died due to lack of feeding is not known.

Table 1. Survival, estimated cannibalism, and mean total length of striped bass larvae exposed to five photoperiods (experiment 1) after 12 days of culture.

Photoperiod	Survival (%)	Cannibalism (%)	Length (mm)
24L/OD	54.2 $\pm$ 6.9	26.4 $\pm$ 9.8	12.6 $\pm$ 0.2
18L/6D	51.4 $\pm$ 2.1	25.8 $\pm$ 4.0	13.0 $\pm$ 0.3*
12L/12D	55.7 $\pm$ 2.4	24.7 $\pm$ 5.0	12.6 $\pm$ 0.2
6L/18D	62.9 $\pm$ 6.0	20.8 $\pm$ 5.9	12.9 $\pm$ 0.1*
0L/24D	54.4 $\pm$ 1.8	27.1 $\pm$ 0.5	11.9 $\pm$ 0.3*
Overall Mean	55.7 $\pm$ 1.9	25.0 $\pm$ 1.1	12.6 $\pm$ 0.2

Value are mean  $\pm$  SEM; n=3 replicates per mean.

\*Only the mean length of 0L/24D was significantly different from those of 18L/6D and 6L/18D (protection level = 0.05).

Near the end of the experiment, some larvae of all sizes began to twirl and swim in a spiral, with mouths gaping. This problem seemed to be equally distributed among all photoperiod treatments. After conclusion of this experiment, larvae in this condition were found to survive for at least 4 days. A sample taken to the Southeastern Cooperative Fish Disease Project (Auburn University, AL) revealed no parasites, but an unidentified bacterium was present. It was not known if this was a cause of fish deaths.

## Effects of photoperiod on striped bass

No significant differences among treatment means due to cannibalism were found (Table 1). This behavior was first observed among 5-day-old larvae. Other attempts at cannibalism were observed during the culture period even though brine shrimp were present.

Larvae grew from an average total length of 5.9mm at stocking to an average total length of 12.6mm. Mean total length of larvae in the OL/24D treatment was significantly less than mean total length of larvae in the 18L/6D and 6L/18D treatments (Table 1).

Water quality appeared suitable for striped bass; pH was 8.1, and water temperature ranged from 22.2°C to 26.1°C. Aeration, salinity, low stocking levels, and other factors should have prevented build-up of toxic metabolites such as ammonia (Trussell, 1972; Sousa et al., 1974; Bonn et al., 1976).

*Experiment 2.* After 9 days of culture, average survival/jar was 87.7%. While survival was higher for hybrid larvae than for striped bass larvae, and for larvae cultured in 24L/OD photoperiod compared to 12L/12D photoperiod, these differences were not significant (Table 2). Daily mortality counts early in the experiment indicated that hybrid larvae may tolerate handling stress related to stocking procedures better than do striped bass larvae; this difference in tolerance to handling possibly was reflected in non-significant differences in survival by the end of the experiment (Table 2).

A few 11-day-old larvae began twirling like those in experiment 1. While numbers exhibiting this behavior increased somewhat, it is not thought that the number of larvae that may have died from this was significant. Due to the appearance of this behavior, the experiment was terminated so that photoperiod effects would not be compromised by this outside influence. At the end of the experiment, moribund fish were observed to have a few bacteria and parasites. While bacteria were not identified, the parasites were identified as *Ichtyobodo* sp. by personnel of the Southeastern Cooperative Fish Disease Project. Their checks for vertebral lesions such as those associated with culture in water with low calcium hardness (Grizzle et al., 1985), and for viruses, proved negative.

Cannibalism was not significantly different between the two fish types or between the two photoperiods (Table 2). The number of larvae thought lost to cannibalism was relatively low compared to results obtained in experiment 1 and past studies (Braid and Shell, 1981). It is not known whether this behavior varies with different groups of larvae, or whether its extent might have increased had experiment 2 lasted longer.

For combined treatments, striped bass grew from an initial total length of 6.0mm to an average length of 10.5mm. Hybrid larvae grew from 6.0mm to an average length of 11.2mm. This difference was highly significant (Table 2). However,

Table 2. Survival, estimated cannibalism, and mean total length of striped bass larvae and hybrid larvae exposed to two photoperiods (experiment 2) after nine days of culture.

Photoperiod	Survival (%)		Cannibalism (%)		Length (mm)	
	Striped Bass	Hybrid	Striped Bass	Hybrid	Striped Bass	Hybrid
24L/0D	85.6 $\pm$ 6.2	92.5 $\pm$ 3.3	4.8 $\pm$ 2.2	3.5 $\pm$ 2.1	10.4 $\pm$ 0.1	11.1 $\pm$ 0.2
12L/12D	82.8 $\pm$ 3.6	89.7 $\pm$ 3.9	4.4 $\pm$ 1.8	7.8 $\pm$ 4.3	10.5 $\pm$ 0.1	11.3 $\pm$ 0.1
Overall Mean	84.2 $\pm$ 1.4	91.1 $\pm$ 1.4	4.6 $\pm$ 0.2	5.6 $\pm$ 2.2	10.5 $\pm$ 0.1*	11.2 $\pm$ 0.1*

Values are mean  $\pm$  SEM; n = 3 replicates per mean.

\*Only the overall mean lengths of striped bass vs. hybrids were significantly different ( $P < 0.01$ ).



## Effects of photoperiod on striped bass

mean differences between photoperiod treatments, and for interaction of fish types with photoperiods, were not significant.

Water quality was similar to that during experiment 1. Temperature ranged from 19.2°C to 22.2°C, and pH was 8.1.

*Behavioral Response of Larvae to Photoperiod Treatments.* Frequently, when jars were uncovered to expose larvae to light for feeding, the larvae followed the bag downward and appeared to be agitated for a brief period. These fish required several minutes to acclimate to the light before they began feeding. This behavior closely resembles that described by Davis (1962) for bluegills (*Lepomis macrochirus*) recovering from light shock after darkness. Near the end of experiment 1, some larvae, especially those in the 18L/6D photoperiod, seemed to be more interested in the light when uncovered than in feeding. This well-known phototactic behavior (Bonn et al., 1976) seemed to interfere with feeding such that some larvae did not feed well or at all during the 0300h feeding.

During the second experiment, similar behavior was observed, especially near termination. Larvae of both types often did not appear to feed quite as well at 2400h. Striped bass larvae in all jars in the 12L/12D photoperiod seemed to not feed as well during the 2100, 2400, and 0300h feedings, but fed well at 0600h. This resembles results in which, over a 20-day period, maximum recovery time of bluegills to light shock was reached within the first 2h of darkness, then gradually decreased (Davis, 1962). This reduced recovery time later in the dark period had been attributed to an internal regulatory rhythm. Since lengths of larvae in the two photoperiod treatments were not significantly different, perhaps any energy conservation benefits of darkness may have been offset by this reduced feeding, or perhaps by the advantage of continuous feeding in constant light. Hybrids in the 12L/12D photoperiod fed well; they seemed to adjust more quickly to sudden illumination. This may in part account for the significantly faster growth of these larvae compared to that of the striped bass.

Striped bass spent more time near the bottom of jars than did the hybrid larvae, which seemed to utilize more of the water column. Whether this behavior decreased competition for brine shrimp among hybrid larvae and thereby improved feeding efficiency is uncertain.

Since the only apparent quantitative effect of photoperiod concerned the significant lack of growth of larvae in the 0L/24D photoperiod in experiment 1, questions arise concerning larval response. It may be that there is no well-defined response to photoperiod among striped bass or hybrid larvae. Or, perhaps there are differences among batches or sources of larvae. Larval response may vary with age of larvae, and these trial periods may have been too short to detect photoperiod effects. For example, effects of photoperiod on food consumption and food conversion efficiency of channel catfish changed with age of fish (Kilambi, 1970).

From these studies on striped bass and hybrid larvae, it appears that the typical short-term hatchery rearing of such larvae under constant indoor lighting is suitable, since no benefits resulted from providing larvae with a dark period.

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#### LITERATURE CITED

- Bishop, R.D. 1967. Evaluation of the striped bass (*Roccus saxatilis*) and white bass (*R. chrysops*) hybrids after two years. Proc. Ann. Conf. S. E. Assoc. Fish Wildl. Agencies 21: 245-254.
- Bonn, E., W.M. Bailey, J.D. Bayless, K.E. Erikson, and R.E. Stevens, eds. 1976. Guidelines for striped bass culture. Special Publ. Striped Bass Committee, So. Div., Am. Fish Soc. 103 pp.
- Braid, M.R. and E.W. Shell. 1981. Incidence of cannibalism among striped bass fry in an intensive culture system. Prog. Fish-Cult. 43:210-212.
- Braid, M.R. 1987. Prime-retaining siphon for use in intensive culture systems. Prog. Fish-Cult. 49:236.
- Davis, R.E. 1962. Daily rhythm in the relation of fish to light. Science 137, 430-432.
- Grizzle, J.M., A.C. Mauldin II, D. Young, and E. Henderson. 1985. Survival of juvenile striped bass (*Morone saxatilis*) and *Morone* hybrid bass (*Morone chrysops* X *Morone saxatilis*) increased by addition of calcium to soft water. Aquaculture 46:167-171.
- Gross, W.L., E.W. Roelofs, and P.O. Fromm. 1965. Influence of photoperiod on growth of green sun-fish *Lepomis cyanellus*. J. Fish. Res. Board Canada 22(6):1379-1386.
- Johnson, D.W. and I. Katavic. 1984. Mortality, growth and swim bladder stress syndrome of sea bass (*Dicentrarchus labrax*) larvae under varied environmental conditions. Aquaculture 38:67-78.

## Effects of photoperiod on striped bass

- Kilambi, R.V., J. Noble, and C.E. Hoffman. 1970. Influence of temperature and photoperiod on growth, food consumption and food conversion efficiency of channel catfish. Proc. Ann. Conf. S.E. Assoc. Fish Wildl. Agencies 24:146-150.
- Laurence, G.C. 1971. Feeding and bioenergetics of largemouth bass larvae (*Micropterus salmoides*). Ph.D. thesis, Cornell Univ. 132 pp.
- Logan, H.J. 1967. Comparison of growth and survival rates of striped bass x white bass hybrids under controlled environments. Proc. Ann. Conf. S.E. Assoc. Fish Wildl. Agencies 21:260-263.
- Rees, R.A. and S.F. cook. 1982. Effects of sunlight intensity on the survival of striped bass x white bass fry. Proc. Ann. Conf. S.E. Assoc. Fish Wildl. Agencies 36:83-94.
- Sousa, R.J., T.L. Meade, and R.E. Wolke. 1974. Reduction of ammonia toxicity by salinity and pH manipulation. Proc. 5th Ann. Workshop, World Maricult. Soc. 4:343-354.
- Steel, R.G.D. and J.H. Torrie. 1960. Principles and procedures of statistics. McGraw-Hill Book Co., Inc., New York. 481 pp.
- Trussell, R.P. 1972. The percent un-ionized ammonia in aqueous ammonia solutions at different pH levels and temperatures. J. Fish. Res. Bd. Canada 29:1505-1507.



## INFLUENCE OF TEMPERATURE, PHOSPHORUS SOURCE AND LEVEL ON GROWTH AND BONE DEVELOPMENT IN CHICKENS<sup>1</sup>

Joseph I. Orban, and David A. Roland, Sr.  
*Poultry Science Department and*  
*Alabama Agricultural Experiment Station<sup>2</sup>*  
*Auburn University, Alabama 36849*

### ABSTRACT

Eight hundred broiler chicks were fed basal corn-soybean diets containing .36% phosphorus to which dicalcium phosphate (DCP) or meat and bone meal (MBM) was added to supply .46, .56, .66, .76, and .86% total phosphorus. Chicks were raised to 3 weeks of age at two temperatures, 29.4°C (low) and 35.0°C (high) with a reduction of 2.8°C each successive week. Feed consumption, feed conversion, body weight gain, tibia weight, tibia strength and percent tibia ash were measured to assess the influence of temperature as well as phosphorus source and level on phosphorus utilization for weight gain and bone development of chickens. Results showed significant reductions in measurements for all criteria except tibia strength at the high temperature. Differences between phosphorus sources were observed only for weight gain. Chicks fed DCP diets had higher weight gain than those fed MBM diets. Chick growth and bone development was quadratically influenced by phosphorus level with a linear response up to .66 or .76% total phosphorus level, and thereafter plateaued or declined. There were interactions of temperature by phosphorus source (weight gain); temperature by phosphorus level and phosphorus source by phosphorus level for tibia weight and tibia ash. Results indicated that environmental temperature, phosphorus source and level, affected the utilization of phosphorus for growth and bone development of broiler chickens.

### INTRODUCTION

Phosphorus is required by chickens for bone formation as well as metabolism of carbohydrates and fat for growth. However, the utilization of phosphorus for these purposes can be affected by several factors. One of the major factors is phosphorus source which could be organic (plant or animal source) or inorganic (mineral source). Plant phosphorus is only 30% available for use by animals. Phosphorus from animal sources is considered to be 100% as available for utilization by chickens as phosphorus from mineral sources (Motzok *et al.*, 1956; Edwards and Gillis, 1959; Spandorf and Leong, 1964; Waldroup *et al.*, 1965; Fritz *et al.*, 1969).

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Other reports have however, indicated that phosphorus from animal sources may not be as available for utilization by chicks as generally thought because of wide variations in phosphorus availability values from these products (Gillis *et al.*, 1954; Scott *et al.*, 1962; Huang and Alee, 1981; Peeler, 1982; Hugue and Jensen, 1985).

Variations in phosphorus availability and utilization from both organic and inorganic sources have been associated with several factors including product source, type or form (Miller and Joukovsky, 1953, Wilcox *et al.*, 1954; McGillivray, 1978; Orban and Roland, 1988); particle size of product (Almquist, 1962; Griffith, 1969; Orban and Roland, 1987; Burnell *et al.*, 1988); digestibility of the phosphorus product (Ketels and DeGroote, 1988); seasonal changes and product quality (Jones, 1989).

As a result of these variations, there is a growing concern among nutritionist and producers concerning phosphorus requirements in poultry nutrition. In a recent survey of some 21 poultry nutritionists, it was found that phosphorus requirement recommendations varied extensively among the nutritionists surveyed (Waldroup, 1989). This indicates that more knowledge concerning phosphorus requirement and utilization is needed to address the phosphorus-associated skeletal problems of bone breakage and splintering often encountered during processing of poultry meat resulting in huge economic losses to the poultry industry.

High ambient temperature has been observed to influence phosphorus utilization (Garlich and McCormick, 1980; McCormick and Garlich, 1982); however, the mechanism by which temperature influences phosphorus utilization is not clearly understood. If phosphorus utilization is related to environmental temperature, it would imply that temperature may contribute to the variations in phosphorus availability and utilization from organic and inorganic sources.

The present study was, therefore, conducted to evaluate the utilization of phosphorus from meat and bone meal (organic source) and feed grade dicalcium phosphate (inorganic source) for growth and bone development of broiler chickens reared under low and high ambient temperatures.

## MATERIALS AND METHODS

Eight hundred day-old Arbor Acres male broiler chickens (Arbor Acres Farm, Inc., Albertville, AL) were fed basal corn-soybean diets to which either meat and bone meal (MBM) or dicalcium phosphate (DCP) was added to supply .46, .56, .66, .76, and .86% total phosphorus (Table 1). Chicks were raised to 3 weeks of age at brooding temperatures of 29.4°C or 35.0°C with a reduction of 2.8°C each successive week. Feed and water were provided *ad libitum*. Chicks were randomly assigned to 20 treatment combinations using a 2 x 2 x 5 factorial arrangement in a complete randomized design. Treatments were replicated four times with 10 birds per

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Table 1. Composition of experimental diets containing dicalcium phosphate or meat and bone meal

Ingredient	Dicalcium phosphate diets and total phosphorus level (%)					Meat and bone meal diets and total phosphorus levels (%)						
	36 <sup>C</sup>	46	56	66	76	86	36 <sup>C</sup>	46	56	66	76	86
Ground yellow corn (8.7% protein)	53.33	53.33	53.33	53.33	51.95	50.18	53.33	56.09	57.47	58.86	59.42	59.51
Dehulled soybean meal (48% protein)	36.80	36.80	36.80	36.80	37.05	37.37	36.80	33.60	30.34	27.08	23.93	20.97
Poultry Fat	5.15	5.15	5.15	5.15	5.65	6.30	5.15	4.24	3.84	3.44	3.34	3.41
Dehydrated alfalfa (17% protein)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Dicalcium phosphate (18.71% P, 21.5% Ca)	...	.53	1.07	1.57	2.12	2.67	...	...	...	...	...	...
Ground limestone (38.8%)	1.91	1.62	1.32	1.04	1.12	1.37	1.91	1.40	.81	.22	...	...
DL-Methionine	.20	.20	.20	.20	.20	.20	.20	.20	.21	.22	.24	.25
Salt (NaCl)	.41	.41	.41	.41	.41	.41	.41	.35	.29	.23	.17	.11
Vitamin premix <sup>A</sup>	.25	.25	.25	.25	.25	.25	.25	.25	.25	.25	.25	.25
Mineral premix <sup>B</sup>	.25	.25	.25	.25	.25	.25	.25	.25	.25	.25	.25	.25
Meat and bone meal (4.86% P, 8.12% Ca)	...	...	...	...	...	...	...	2.62	5.54	8.45	11.40	14.25
Sand (filler)	.70	.46	.22	...	...	...	.70	...	...	...	...	...
Total	100	100	100	100	100	100	100	100	100	100	100	100
Calculated nutrient composition												
Protein-crude (%)	22.62	22.62	22.62	22.62	22.62	22.62	22.62	22.62	22.62	22.62	22.62	22.62
ME/kg (kcal/kg)	3157	3157	3157	3157	3157	3157	3157	3157	3157	3157	3157	3157
Calcium (%)	.95	.95	.95	.95	1.10	1.32	.95	.95	.95	.95	1.10	1.32
Total phosphorus (%)	.36	.46	.56	.66	.76	.86	.36	.46	.56	.66	.76	.86
Available phosphorus (%)	.11	.22	.33	.44	.55	.66	.11	.22	.33	.44	.55	.66
Sodium (%)	.19	.19	.19	.19	.19	.19	.19	.19	.19	.19	.19	.19
Methionine (%)	.57	.57	.57	.57	.57	.57	.57	.58	.59	.60	.62	.62
Methionine + cystine (%)	.92	.92	.92	.92	.92	.92	.92	.92	.92	.92	.92	.92

<sup>A</sup>Vitamin premix provided the following per kg: vitamin A, 1,334, 600 IU; vitamin D<sub>3</sub>, 400,000 IU; vitamin E, 1,456 IU; riboflavin, 1,000 mg; d-pantothenic acid, 2,364 mg; d-calcium pantothenate 2, 568 mg; niacin, 6,544 mg; choline chloride, 104,726 mg; vitamin B<sub>12</sub>, 3.6 mg; menadione, 364 mg; folic acid, 92 mg; thiamine monitrate, 196 mg; pyridoxine hydrochloride, 486 mg; d-biotin, 9 mg.

<sup>B</sup>Mineral premix contained iodine, .04%; copper, .2406%; manganese, 2.6036%; selenium, .012%; cobalt, .008%; iron, 2.2026% and Zinc, 2.2026%.

<sup>C</sup>Basal diet without added dicalcium phosphate or meat and bone meal.



replicate. Chicks were raised in Petersime battery units in two identical rooms in a brooder house with controlled heating and ventilating systems. The starting brooding temperature was set at 29.4°C in one room and 35.0° in the other.

Feed consumption and body weight were measured weekly. At the end of 3 weeks, all birds were killed by cervical dislocation and tibiae of both legs were removed, cleaned of flesh, air-dried (72 hours) and analyzed for weight, breaking strength and percent ash. Tibia breaking strength (force (kg) necessary to break each tibia) was measured using a universal testing machine, Instron (model 1122, Instron Corporation, Canton, MA). Tibiae were supported by a fulcrum 3.4 cm apart and force was applied to the midpoint of the tibiae by a probe (1.4 cm in length and 1.3 cm in width at the base) at a crosshead speed of 200 mm/min. The broken bones were weighed in individual crucibles and ashed at 600°C for 6 hours.

The criteria used to assess phosphorus utilization by chicks for growth were feed consumption, body weight and feed conversion (feed intake ÷ weight gain). Bone development was assessed using tibia weight, tibia breaking strength and percent tibia ash (tibia ash weight ÷ tibia weight x 100). Mortality due to treatment effect was also recorded.

Data obtained representing means in each pen were subjected to analysis of variance (Steel and Torrie, 1980). Phosphorus sources and levels were compared using polynomial contrasts of means.

## RESULTS AND DISCUSSION

### *Chick Growth as Affected by Temperature, Phosphorus Source and Level*

Feed consumption and weight gain by chicks were significantly reduced at high temperature (Table 2). This is a typical response of broilers to high environmental temperature as reported by others (Charles, 1980; Dale and Fuller, 1980; Hurtwiz et al., 1980; Wilson 1980; Charles et al., 1981; Meltzer, 1983, 1984; Teeter, 1987; Howlinder and Rose 1988, 1989). Heat production in broilers is controlled in part by dietary nutrients available for metabolism; therefore, broilers reduce their heat production by reducing feed consumption as ambient temperature exceeds the zone of thermo-neutrality.

Although reduced feed consumption can be incriminated for weight gain depression during periods of heat stress, Dale and Fuller (1980) observed that growth rate was significantly reduced in 4 wk broilers in a hot chamber (33°C), but feed intake of heat stressed chicks was the same as for pair-fed chicks held at cool temperature (22°). Howlinder and Rose (1989) observed a similar trend that broilers reared at 21° or 31°C consumed similar quantities of feed to reach their slaughter weight. In the present study, both feed intake and weight gain were reduced by high temperature.

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Table 2. Effect of temperature, phosphorus source - dicalcium phosphate (DCP) or meat and bone meal (MBM), and phosphorus level on feed consumption (FCS), weight gain (WTG), feed conversion (FCV), tibia weight (TBW), tibia strength (TBS and tibia ash (TBA) of broilers at 3 weeks of age

Treatment effect	FCS (g)	WTG (g)	FCV (F/G)	TBW (g) (kg/cm <sup>2</sup> )	TBS	TBA (%)
Temperature (°C)	*	*	**	**	NS	**
29.4 - 23.9 (Low)	921	591	1.56	1.90	17.8	45.6
35.0 - 29.4 (High)	850	579	1.47	1.81	17.3	43.7
Phosphorus source	NS	*	NS	NS	NS	NS
DCP	892	591	1.51	1.87	17.6	44.8
MBM	878	578	1.52	1.84	17.4	44.5
Phosphorus level (total) (%)	**	**	*	**	**	**
.46	760	490	1.55	1.44	15.9	36.8
.56	877	576	1.52	1.71	16.8	42.7
.66	937	617	1.52	2.02	17.3	47.3
.76	928	622	1.49	2.07	18.4	48.2
.86	926	617	1.50	2.06	19.1	48.3
Pooled SEM	20	12	.02	.05	.9	.4
Contrasts						
Phosphorus source at low temperature (LT)	NS	NS	NS	NS	NS	NS
Phosphorus source at high temperature (HT)	NS	**	NS	NS	NS	*
Phosphorus level linear (LT and HT)	**	**	**	**	**	**
Phosphorus level quadratic (LT and HT)	**	**	NS	**	NS	**

\*P < .05.

\*\*P < .01.

NS = not significant (P > .05).

F/G = feed consumption ÷ weight gain.

SEM = Standard error of mean

Feed conversion was improved at high temperature (Table 2). High temperature has greater savings in feed utilization (Howlader and Rose, 1988); however, at ambient temperatures above 28°C, even feed efficiency is reduced especially in male broilers (Meltzer, 1984).

Broiler weight gain was affected by phosphorus source. Chicks fed the DCP diets had higher weight gain than birds fed MBM diets (Table 2); furthermore, results indicated an interaction of phosphorus source and temperature. That is, the differences in weight gain as influenced by the two phosphorus sources was greater at the high brooding temperature than it was at the low temperature (Figure 1). Results suggest that the utilization of phosphorus for broiler growth may be influenced by environmental temperature and the source of phosphorus supplement. The interaction of temperature and phosphorus source reflected in weight gain of broilers in the present study signals the need to consider the formulation of poultry diets relative to environmental temperature, season or geographical location with appropriate nutrient density. If there is rapid decline in feed intake as temperature rises, the resulting decline in nutrient intake per day will cause depression in growth, unless feed nutrient density is increased (Wilson, 1980).

Feed consumption and weight gain by chicks were also influenced quadratically by phosphorus level in the diet (Table 2). The response was linear up to .66 or .76% phosphorus and then plateaued or declined.

#### *Bone Development in Chicks as Influenced by Temperature, Phosphorus Source and Level*

Figure 3 illustrates bone development as influenced by phosphorus source and level. Although tibial weight and percent ash were significantly reduced at high temperature (Table 2), the breaking strength of these bones was not affected by differences in temperature. Bone quality (weight, strength and ash) was not affected by the source of phosphorus utilized; however, the level of phosphorus in the diet resulted in a quadratic response for tibial weight and percent ash and a linear response for tibial breaking strength as shown in Table 2 and Figure 3.

There were interactions of temperature by phosphorus level and source on tibia weight (Figure 2A and B) and tibia ash (Figure 2C and D). Broiler response to phosphorus level with respect to tibia weight and ash was similar (quadratic), however, broilers reared at low temperature had higher tibia weight and ash (Figure 2A and C). At phosphorus level below .66%, DCP was better utilized for tibia weight and ash than MBM; however, when phosphorus level was .66% or above, both phosphorus sources were utilized to the same extent (Figure 2B and D).

Although there was no difference in bone quality with respect to phosphorus sources, it is noteworthy that temperature affected the manner in which the phosphorus sources (DCP or MBM) were being utilized for tibial development at various phosphorus levels.



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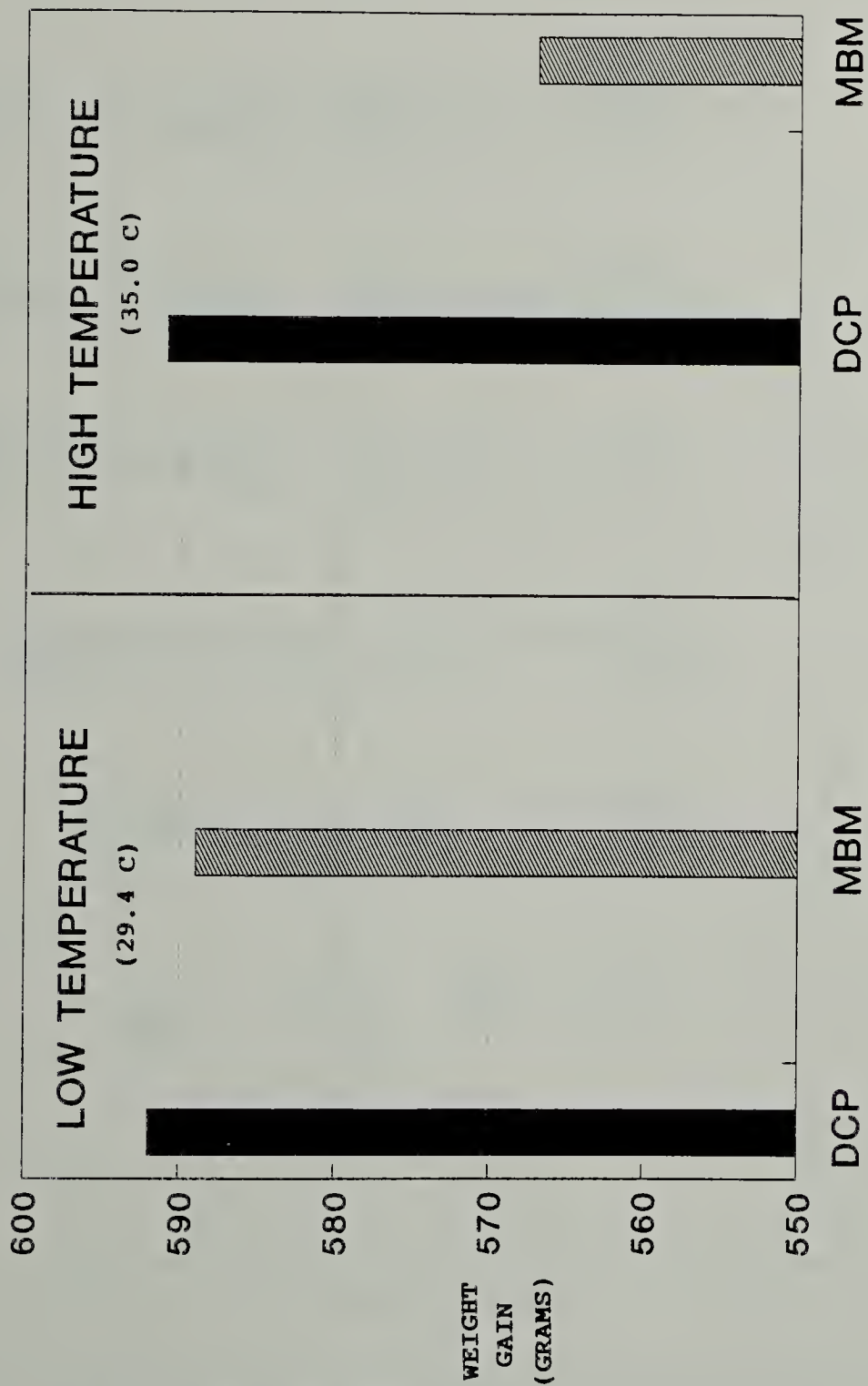


Figure 1. Effect of interaction of temperature and phosphorus source on weight gain of 3-week-old broilers. DCP = Dicalcium phosphate; MBM = Meat and bone meal.

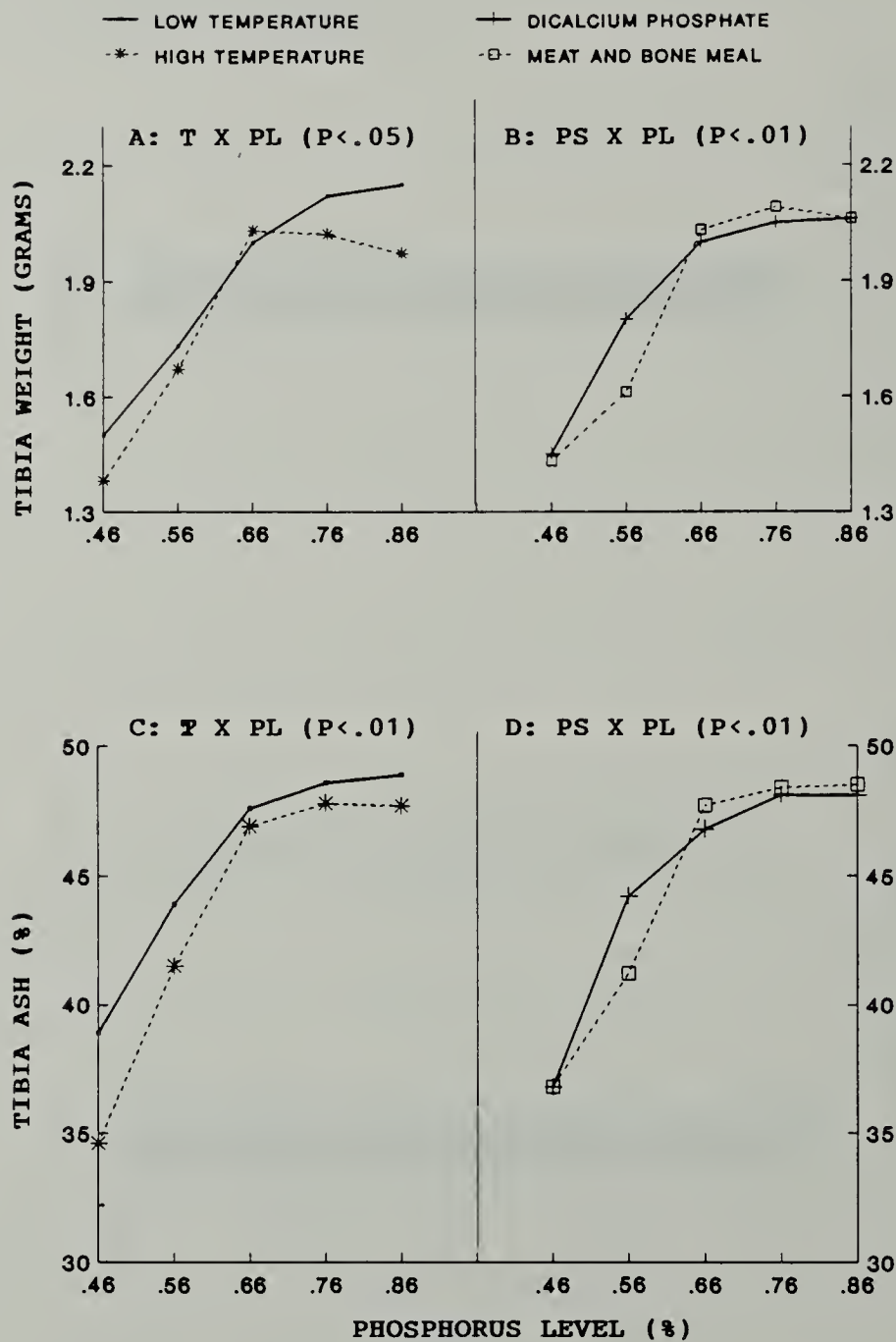


Figure 2. Effect of interactions of temperature and phosphorus level (T X PL) and of phosphorus source and phosphorus level (PS X PL) on tibia weight (A and B) and tibia ash (C and D) of 3-week-old broilers.

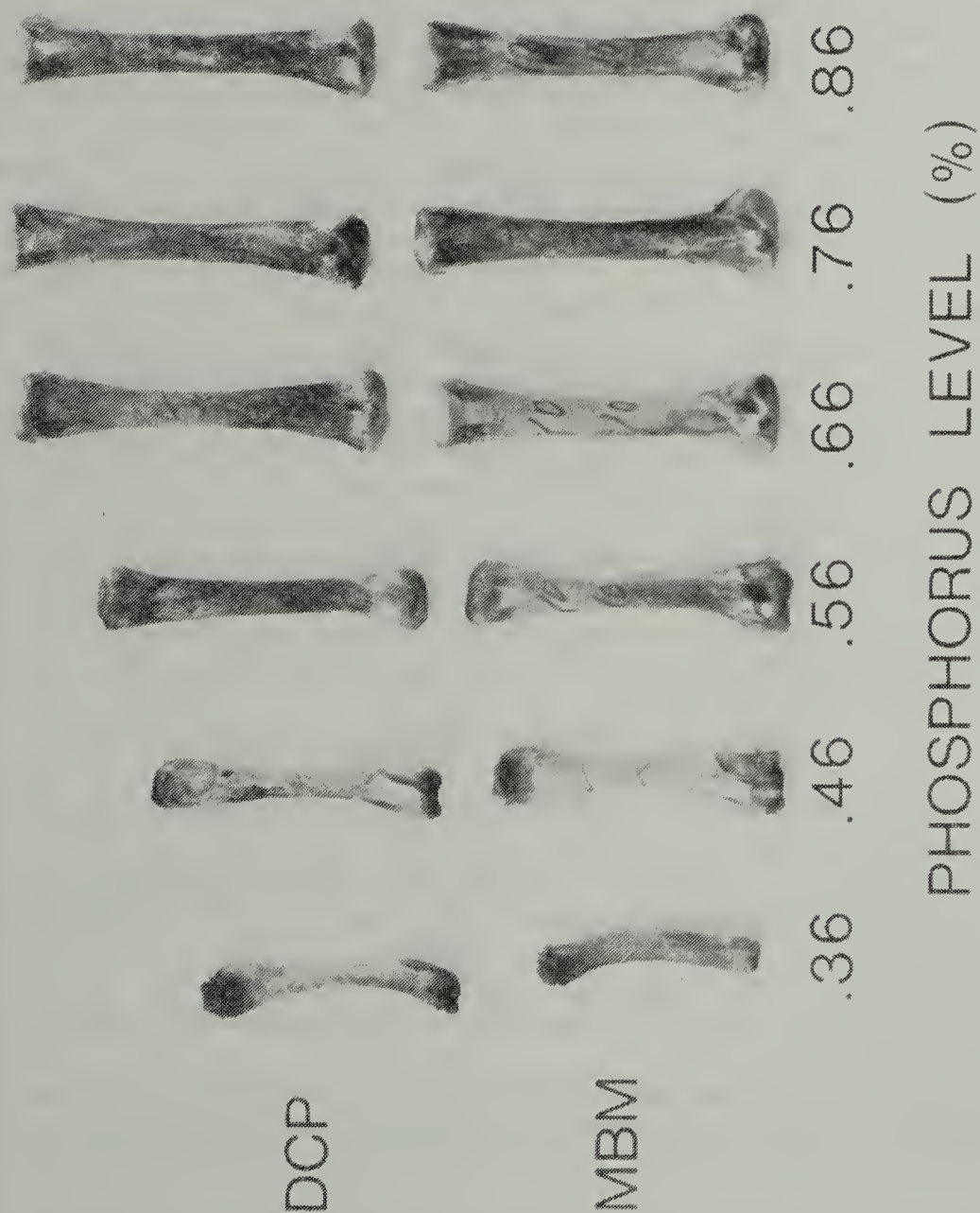


Figure 3. Tibiae of 3-week-old broiler chicks fed phosphorus from dicalcium phosphate (DCP) or meat and bone meal (MBM). Chicks fed .36% phosphorus were fed only basal diet without added DCP or MBM.



Temperature needs to be considered among other factors in evaluating the extent to which a phosphorus supplement can be utilized since it may affect nutrient intake and the overall performance and livability of chickens. During heat stress, the plasma concentration of inorganic phosphate decreases approximately 40% and chicks which consume diet which is inadequate in phosphate will have subnormal phosphate concentrations (Garlich and McCormick, 1980). The survival of chicks during high temperatures or heat stress also depends on the amount of phosphorus available to the chicken. McCormick and Garlich (1982) reported that chicks fed .55% available phosphorus had longer survival times when exposed to heat stress than chicks fed .35% available phosphorus.

In the present study, mortality was not influenced by differences in brooding temperature, phosphorus source or phosphorus level. Total mortality based on phosphorus source was 11/200 for DCP-birds and 3/200 for MBM-birds at low temperature. At the high temperature, the total mortality was 4/200 for DCP-birds and 6/200 for MBM-birds. Based on the results of this study, it was concluded that environmental temperature, phosphorus source and phosphorus level play influential roles in phosphorus utilization in broiler chickens for growth and bone development. Because heat stress is a frequent problem in broiler production, it is important to consider formulating broiler diets relative to environmental temperature or season or geographical location thereby selecting economical and optimal combination of nutrition and environmental temperature to obtain optimum productivity.

#### LITERATURE CITED

- Almquist, H. J., 1962. Soft phosphate in poultry nutrition. *Feedstuffs* 34:62-67.
- Burnell, T. W., G. L. Cromwell, and T. S. Stahly, 1988. Effects of particle size on the availability of phosphorus in defluorinated phosphate for pigs. *J. Anim. Sci.* 66: 140.
- Charles, D. R., 1980. Environment for Poultry. *Veterinary Record*. 106: 307-309.
- Charles, D. R., C. M. Groom, and T. S. Bray, 1981. The effects of temperature on broilers: Interactions between temperature and feeding regime. *British Poultry Sci.* 22: 475-481.
- Dale, N. M., and H. L. Fuller, 1980. Effect of diet composition and feed intake and growth of chicks under stress. II. Constant vs cycling temperatures. *Poultry Sci.* 59: 1434-1441.
- Edwards, H. M., Jr., and M. B. Gillis, 1959. A chromic balance method for determining phosphate availability. *Poultry Sci.* 38: 569-574.

## Growth and bone development in chickens

- Fritz, J. C., T. Roberts, J. W. Boehne, and E. L. Hove, 1969. Factors affecting the chicks requirement for phosphorus. *Poultry Sci.* 48: 307-320.
- Garlich, J. D., and C. C. McCormick, 1980. Phosphorus, calcium and heat stress in hens and broilers. *Proceedings of Maryland Nutrition Conference.* pp. 25-27.
- Gillis, M. B., Norris, L. C., and Heuser, G. F., 1954. Studies on the biological value of inorganic phosphate. *J. Nutr.* 62: 115-126.
- Griffith, M., 1969. Influence of dietary particle size and composition on phosphorus availability. *Poultry Sci.* 48: 1255-1261.
- Huang, K. C., and G. L. Alee, 1981. Bioavailability of phosphorus in selected feedstuffs for young chicks and pigs. *J. Anim. Sci.* 53: 248.
- Howlider, M. A. R., and S. P. Rose, 1988. Temperature and growth of broilers. *World's Poultry Science Journal* 43: 228-237.
- Howlider, M. A. R., and S. P. Rose, 1989. Rearing temperature and the meat yield of broilers. *British Poultry Sci.* 30: 61-67.
- Hugue, Q. M. E., and J. F. Jensen, 1985. Biological availability of selenium and phosphorus in fish meal as affected by condition of fish and type of meal. *British Poultry Sci.* 26: 289-297.
- Hurtwiz, S., M. Weiselberg, U. Eisner, I. Barfov, G. Riesenfeld, M. Sharvit, A. Niv, and S. Bornstein, 1980. The energy requirements and performance of growing chickens and turkeys as affected by environmental temperature. *Poultry Sci.* 59: 2290-2299.
- Jones, F. T., 1989. Feed ingredient quality. Pages 1-6 in: *Proc. of the Texasgulf Nutr. Symposium*, Raleigh, NC.
- Ketels, E., and G. DeGroote, 1988. The relative bioavailability and ileal digestibility of phosphorus from mineral and animal sources. Pages 873-874 in: *Proc. XVIII World's Poultry Congress*, Nagoya, Japan.
- McCormick, C. C., and J. D. Garlich, 1982. The interaction of phosphorus nutrition in the fasting on the survival time of young chickens exposed to high temperature. *Poultry Sci.* 61: 331-336.
- McGillivray, J. J., 1978. Biological availability of phosphorus sources. Pages 73-85 in: *Proc. First Ann. Intl. Minerals Conference*, IMC Corporation, Mundelein, IL.

Orban and Roland

- Meltzer, A., 1983. The effect of body temperature on growth rate of broilers. *British Poultry Sci.* 24: 489-495.
- Meltzer, A., 1984. Effect of temperature and relative humidity on feed conversion in broilers. Pages 161-162. In: *Proceedings of the World's Poultry Sci. Assoc.*, 17th Congress, Helsinki.
- Miller, M. W., and V. Y. Joukovsky, 1953. Availability of phosphorus from various phosphate materials for chicks. *Poultry Sci.* 35: 627-699.
- Motzok, I., D. K. Authur, and H. D. Branion, 1956. Utilization of phosphorus from various phosphate supplements by chicks. *Poultry Sci.* 35: 627-699.
- Orban, J. I., and D. A. Roland, Sr., 1987. The effect of particle size on phosphorus availability from chicken bone meal. *Poultry Sci.* 66 (Suppl. 1):32.
- Orban, J. I., and D. A. Roland, Sr., 1988. Performance of broilers fed different sources of bone meal and the response of various broiler strains to dietary phosphorus and environmental temperature. *Poultry Sci.* 67 (Suppl. 1:27).
- Peeler, H. T., 1982. Phosphorus - A review. Pages 1-23 in: *Proc. 5th Ann. Intl. Minerals Conf.*, Mundelein, IL.
- Scott, M. L., H. W. Butters, and G. O. Ranit, 1962. Studies on the requirements of young poult for available phosphorus. *J. Nutr.* 78: 223-230.
- Spandorf, A. H., and K. C. Leong, 1964. The biological availability of calcium and phosphorus in menhaden fish meals. *Poultry Sci.* 42: 1364-1365.
- Steel, R. G. D., and J. H. Torrie, 1980. *Principles and procedures of statistics.* 2nd ed. McGraw-Hill, Inc., New York, NY.
- Teeter, R. G., M. O. Smith, S. S. Sangiah, and F. B. Mather, 1987. Effects of feed intake and fasting duration upon body temperature and survival of thermostressed broilers. *Nutr. Reports International* 35: 521-537.
- Waldroup, P. W., 1989. Phosphorus in broiler nutrition. *Nutrition Symposium*, Raleigh, NC.
- Waldroup, P. W., C. B. Ammerman, and R. H. Harms, 1965. The utilization of phosphorus from animal protein sources for chicks. *Poultry Sci.* 44: 1302-1306.



## Growth and bone development in chickens

- Wilcox, R. A., C. W. Carlson, W. M. Kohlmeyer, and G. F. Gastler, 1954. The availability of phosphorus from different sources for poult fed purified diets. *Poultry Sci.* 33: 1010-1014.
- Wilson, B. J., 1980. Growth in birds for meat production. Pages 265-272. In: *Growth in Animals. Studies in the agricultural and food sciences.* Butterworths and Co., Ltd., London, U.K.

## A FIXED TARGET EXPERIMENT AT THE SUPERCONDUCTING SUPER COLLIDER<sup>1,2</sup>

C. M. Jenkins  
*Department of Physics*  
*University of South Alabama*  
*Mobile, AL 36688*

### ABSTRACT

The Superconducting Super Collider (SSC) is expected to be constructed and taking data by the year 2000. The well publicized experiments are collider types of experiments where the counter circulating beams are focused onto a small area where the protons collide head on for the maximum center of mass energy. However, a unique experiment (the Super Fixed Target or SFT) has been proposed that uses a fixed target configuration where a single 20 TeV proton beam is extracted from the accelerator and directed onto a fixed metal target. The beam extraction method must be compatible with operating the accelerator in the colliding mode. Currently, the front running method is crystal extraction. This experiment will study the production of B mesons, and various decay properties including: lifetimes of individual B meson species, B and anti B meson mixing, observation of rare B decay modes, and possibly CP violation.

### INTRODUCTION

The Superconducting Super Collider (SSC) is a 20 TeV proton-proton collider to be built south of Dallas, Texas. The accelerator will have a circumference of

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<sup>2</sup>For the Super Fixed Target Collaboration. University of Athens, Bratislava University, University of California Berkeley, University of California at Los Angeles, Carnegie Mellon, Duke University, Dubna, Erevan State University, Fermilab, University of Houston, Gomel State University, Institute of Experimental Physics Kosice, Lebedev Physical Institute, University of Lecce and INFN, Leningrad Institute, Los Alamos National Laboratory, Northwestern University, Institute of Physics Berlorussian Academy of Science, McGill University, University of New Mexico, Oak Ridge National Laboratory, Nanjing University, Northern Illinois University, University of Pavia and INFN, University of Pennsylvania, Shandong University, University of South Alabama, University of South Carolina, State University of New York, Institute of High Energy Physics of Tbilisi University, Sofia University, SSC Laboratory, University of Texas at Austin, University of Wisconsin, Vanier College, University of Virginia.

approximately 87 Km (about 54 miles) and will accelerate protons to 20 TeV in two counter circulating directions in a single tunnel. The accelerator will focus the two counter rotating beams of protons together at various sites (interaction regions which are surrounded by huge cylindrical geometry spectrometers) so that the beams collide head on with a total center of mass energy of 40 TeV. This large center of mass energy will allow for the search of new phenomena such as the Higgs boson, possible supersymmetric particles, and possible structure to current point-like fundamental particles. The SSC is scheduled to be turned on in 1998 for shakedown of the accelerator and the experiments with the first physics runs commencing in the following year.

Our collaboration has proposed to extract part of one of the 20 TeV proton beams and direct it to a fixed target to study B mesons.<sup>3</sup> This proposal (the Super Fixed Target or SFT) is receiving serious consideration from the SSC laboratory and Physics Advisory Panel. The method of beam extraction must allow the SSC to simultaneously run in the collider mode of operation. The 20 TeV proton beam will be directed to a conventional fixed target spectrometer similar to others located at Fermilab and CERN. B mesons are short lived objects ( $11.2 \times 10^{-13}$  sec)<sup>4</sup> and have a small average value of momentum in collider experiments. However, B mesons produced in a fixed target configuration have a large momentum. Although the overall production rate of B mesons will be much lower in the fixed target experiment (due to the lower center of mass energy), the total number of reconstructed B mesons will be larger (due to the larger distance traveled by the B meson). In addition the B mesons and other secondary particles produced from collisions in a fixed target configuration travel in a narrow forward cone. This reduces considerably the solid angle required to detect a substantial fraction of the B mesons and, therefore, reduces the cost of building the spectrometer.

Currently the fundamental particles of nature (particles believed to be point-like) are the leptons (electrons, muon, tau, each in a doublet with its own neutrino), quarks (that come in the flavor doublets: up and down, charm and strange, top and beauty) and gauge bosons which mediate the fundamental forces of nature (photon,  $W^\pm$  and  $Z^0$ , and the gluon). Observed sub-atomic particles are constructed from these fundamental particles and fall into two broad classes: particles which interact via the strong "nuclear" interaction called hadrons (which include protons, neutrons, and pions), and particles that do not interact strongly called leptons. Hadrons are further classified into two groups: baryons that have three quarks (an example is the proton), and mesons which have a quark and anti-quark (an example is a pion). B mesons are pion-like objects that have a single beauty quark (or anti-quark) and any other type of anti-quark (or quark).

## B PHYSICS AND CP VIOLATION

B mesons are relatively massive ( $5.28 \text{ GeV}/c^2$ , about 5.6 times the mass of the proton) and have a life time of  $11.2 \times 10^{-13}$  sec.<sup>4</sup> Because of the large mass of the B



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mesons, they decay into many final state particles. The large number of particles in the final state increases the difficulty of reconstructing the parent B meson. To date, on the order of hundreds of B mesons have been reconstructed at electron positron colliders which is a relatively clean way of producing B's as the collider is tuned to the energy of an excited  $\tau$  (4S) state (composed of a  $b\bar{b}$  quarks) which has a decay channel into B mesons. Hadronic interactions offer higher cross sections for B meson production but introduce other problems. B mesons produced in hadronic interactions are accompanied by other particles produced in the primary collision. To reconstruct the B meson, the B's final state particles must be separated from the other particles produced in the primary collision.

The motivation for studying B mesons transcends spectroscopy: cataloging the existence, production cross sections, lifetimes, etc. of the various B mesons. Theoretically, it is believed that the neutral B mesons system may exhibit CP violation.<sup>5</sup> To explain CP violation a small review of history is needed.

Parity (P) is the operation that maps the coordinates x, y and z into the coordinates -x, -y and -z (or coordinate inversion). Initially it was believed that all physical processes were invariant under such a transformation. In 1956 a pair of particles was discovered that had the same mass and lifetime but decayed via the weak (beta decay) interaction into two different parity states: the  $\theta$ - $\tau$  paradox. T. D. Lee and C. N. Yang deduced after an extensive literature search, that there was no experimental evidence that required the weak interaction to be invariant under parity transformation.<sup>6,12</sup> They proposed that parity inversion was not conserved by the weak interaction and that the  $\theta$  and  $\tau$  were the same particle. This particle was the charged K meson, similar to the pion except one of the quarks (anti-quarks) was a strange quark. The  $\theta$ - $\tau$  decay modes for the  $K^+$  are shown below:

	Decay Mode	Branching Ratio	Parity
$\theta$ :	$K^+ \rightarrow \pi^+\pi^0$	21.2%	+parity
$\tau$ :	$K^+ \rightarrow \pi^+\pi^+\pi^-$	5.6%	-parity
	$K^+ \rightarrow \pi^+\pi^0\pi^0$	1.7%	-parity

In the following year C. S. Wu experimentally confirmed the hypothesis by measuring the distribution of electrons emitted from the beta decay of polarized  $^{60}\text{Co}$  nuclei. The observed asymmetry in the decay distribution signaled that parity was not conserved in the weak beta decay interaction.

There are two other exchange type operations other than the parity operator: charge conjugation and time reversal. The charge conjugation operator (C) maps particle into anti-particle. This operator flips the electric charge, the magnetic moment and the particle quantum number (baryon number or lepton number

changes sign). Mass, momentum and spin of the particle remain unchanged. The other operator is the time reversal operator (T) which reflects the time coordinate. Consequences include that the reaction rate for a particular process is the same as that for the time reversed process. All possible physical processes are believed to be symmetric under the operation of all three operators (TCP theorem). When non-conservation of parity in the weak interaction was discovered theorists reasoned that symmetry may be restored if the two operators CP were simultaneously applied (CP invariance).

Violation of CP invariance was discovered in the decay of the neutral kaon ( $K^0$ ) by Cronin and Fitch in an experiment conducted in 1964.<sup>13</sup> Neutral kaons are produced by the strong interaction, but decay via the weak interaction. The  $K^0$  strong eigenstates are mixtures of the  $K^0$  weak eigenstates. Therefore strongly produced neutral  $K^0$  (or the anti-particle  $\bar{K}^0$ ) may decay via a two pion neutral state (which is a CP + state) or a three pion neutral state (which is a CP - state). If the weak interaction is CP invariant, then the weak eigenstates are represented by these CP eigenstates. It was observed early that the two pion component of  $K^0$  ( $\bar{K}^0$ ) decay had a shorter lifetime ( $9 \times 10^{-11}$  sec) than the three pion  $K^0$  ( $\bar{K}^0$ ) decay ( $5 \times 10^{-8}$  sec) as well as minutely different mass.<sup>4,6</sup> Hence, these different states were referred to as " $K_{\text{short}}$ " and " $K_{\text{long}}$ ".

Produce Eigenstate	Decay Eigenstate (or Physically observed particle)		Lifetime (sec)	CP
$ K^0\rangle$	$ K_1\rangle = [ K^0\rangle +  \bar{K}^0\rangle] / \sqrt{2} \rightarrow \pi\pi$	" $K_{\text{short}}$ "	$9 \times 10^{-11}$	+
$ K^0\rangle$	$ K_2\rangle = [ K^0\rangle -  \bar{K}^0\rangle] / \sqrt{2} \rightarrow \pi\pi\pi$	" $K_{\text{long}}$ "	$5 \times 10^{-8}$	-

The Cronin and Fitch experiment produced  $K^0$ 's upstream of a spectrometer allowing the  $K_{\text{short}}$  component to decay out and leaving only  $K_{\text{long}}$ . The  $K_{\text{long}}$  decays were reconstructed in the spectrometer. They observed a non-zero branching ratio of  $K_{\text{long}}$  into two pions on the order of  $10^{-3}$ . This signaled that the weak interaction was not CP invariant.

The importance of the neutral B meson system is that it is the only other system where CP violation is expected to be observed. Observation of CP violation in the B system requires that the two B mesons produced be detected (as the B mesons were ultimately formed by the creation of a b quark anti-quark pair, so B particles are produced in pairs). One B meson is studied, while the second B meson tags the particle (or antiparticle) identity of the first B meson at production time. The second B meson must be a charged B meson in order to establish the particle or antiparticle nature of the second particle. Different distributions of the studied B meson may be measured to determine if CP violation is present. One of the easiest CP violation signatures occurs in the decay distribution of  $B^0$  mesons decaying into CP eigenstates:

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$$\begin{aligned}
 B^0 \text{ or } \bar{B}^0 &\rightarrow J/\psi + K_{\text{short}} \\
 B^0 \text{ or } \bar{B}^0 &\rightarrow J/\psi + \pi^+ \pi^- \\
 B^0 \text{ or } \bar{B}^0 &\rightarrow J/\psi + \phi
 \end{aligned}$$

Where the  $J/\psi$  is a meson composed of a charm and anti-charm quark. The time distribution for these decays are:<sup>5,7</sup>

$$\begin{aligned}
 \Gamma(B^0 \rightarrow f) &= |\langle f | B^0 \rangle|^2 e^{-\Gamma \tau} [1 + \text{Im} \lambda \sin(\Delta m \tau)] \\
 \Gamma(\bar{B}^0 \rightarrow f) &= |\langle f | \bar{B}^0 \rangle|^2 e^{-\Gamma \tau} [1 - \text{Im} \lambda \sin(\Delta m \tau)]
 \end{aligned}$$

Where the parent  $B^0$  (or  $\bar{B}^0$ ) decays into the CP eigenstate  $f$ , and  $\Delta m$  is the mass difference between the two physically observed B states. CP violation is signaled by a non-zero value of  $\text{Im} \lambda$ . The presence of CP violation can yield dramatic differences in the decay distributions between  $B^0$  and  $\bar{B}^0$  into CP eigenstates. An experiment using this technique to detect CP violation in the neutral B meson system must detect two mesons (one of which is neutral), determine the particle or anti-particle identity of the neutral B meson at production time by the second B particle present in the event, then measure the neutral B meson's decay time distribution. A large enough sample of  $B^0$  and  $\bar{B}^0$  must be accumulated to observe any differences in their decay distributions.

The larger the center of mass energy the larger the number of raw B particles that will be produced. The collider types of experiments have the larger center of mass energy (thus the larger raw production rates of B particles as seen in Table I), but there are several characteristics conspiring to reduce the final number of B mesons that are fully reconstructed. The B particles produced are superimposed on events with a large number of other unassociated particles (multiplicities of a few hundred). B mesons produced in collider experiments have relatively low momentum (43 GeV/c for SSC center of mass energy) that allows the B to travel only 1.3 cm in the laboratory frame. This increases the difficulty of measuring the lifetime of individual B's.<sup>7</sup>

Fixed target experiments are handicapped by the lower production rates, but have advantages that enable a larger reconstruction efficiency of B's. The B mesons will have a larger average momentum. From Table I it can be seen that this large average momentum for B mesons results in the B traveling a larger distance in the laboratory at Fermilab fixed target energies (800 GeV/c protons) than even SSC collider produced B mesons. At SSC fixed target energy the average momentum of a B meson is 445 GeV which allows the B meson to travel 9.5 cm (see Figure 1). B mesons traveling this distance will pass through 54 silicon strip detector planes in the proposed the SFT spectrometer, enabling direct observation of the charged B's track and clean separation for many of the primary production and decay vertices of the



Table I

Important Parameters Of Beauty Production  
in Various Hadronic Experimental Configurations

	TeV II Fixed Target (Fermilab)	TeV I (Fermilab collider)	SSC Collider	SSC Fixed Target
Interaction rate	$10^7$ to $10^8/\text{sec}$	$10^5/\text{sec}^*$	$10^7/\text{sec}^{**}$	$10^7/\text{sec}$
$\sigma$ ( $pN \rightarrow B\bar{B}$ ) <sup>+</sup>	10 nb	20 $\mu\text{b}$	200-500 $\mu\text{b}$	2.5-10 $\mu\text{b}$
$B\bar{B}$ per $10^7$ sec	$10^7$ - $10^8$	$4 \times 10^8$	$2 \times 10^{11}$ - $5 \times 10^{11}$	$10^{10}$ - $5 \times 10^{10}$
$\sigma(B\bar{B})/\sigma_T$ <sup>***</sup>	1/125.0000	1/2500	1/500 - 1/200	1/7700 - 1/1900
Multiplicity	15	45	"few" hundred	20
$\langle P_b \rangle$ in GeV/c	143	38	51	635
$\langle P_B \rangle$ in GeV/c	118	22	43	445
$\langle P_\mu \rangle$ in GeV/c	32	13	36	280
Median B Decay Length	8 mm	1.5 mm	3 mm	42 mm
Mean B Decay Length	16 mm	4.7 mm	13 mm	95 mm

\* Present luminosity  $\approx 10^{30} \text{ cm}^2 \text{ s}^{-1}$  for the Fermilab Collider. Presuming the injector upgrades and corresponding detector upgrades to take advantage of higher luminosity this may increase to  $5 \times 10^{31} \text{ cm}^2 \text{ s}^{-1}$ .

\*\*  $10^7$  interactions per second is taken as a limit for high rate  $4\pi$  B physics collider detector to avoid the problems of multiple high multiplicity events per crossing.

\*\*\* Taking into account the atomic number enhancement of heavy flavor cross sections in heavy targets relative to the total cross section.  $\sigma_T$  is the total cross section.

\* Based on third order  $\alpha_s$  calculations by K. Ellis et al., Workshop on 20 TeV Fixed Target Beauty Facility at the SSC, Fermilab, November 1989.

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$B^0$ . Other advantages of the fixed target experiment include a relatively low average event multiplicity (about 20 particles), where these secondary particles are directed in a forward cone that reduces the solid angle coverage, and the enhancement of production of B mesons (due to hard scatters) vs the total inelastic cross section.

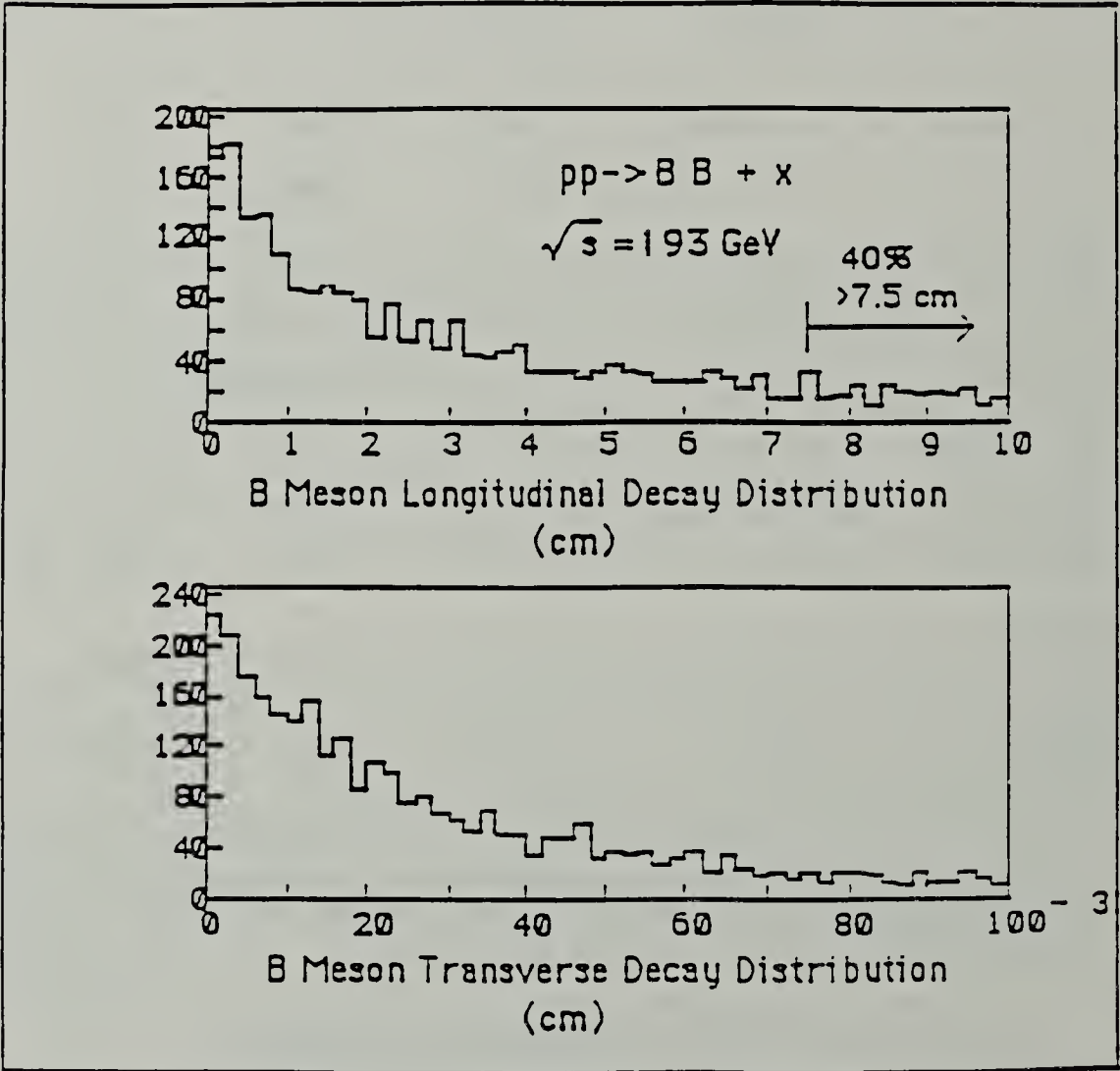


Figure 1. Production of B mesons from 20 TeV protons onto a proton target was simulated with the Pythia monte carol package. The generated B mesons were allowed to decay and the separation between the primary (event) production vertex and the decay vertex was plotted for individual events. Figure 1a: separation along the beam direction. Figure 1b: separation transverse to the beam direction.

From Table I it can be seen that the number of beauty particles per interaction for SSC fixed target experiment ranges from 1/1900 to 1/7700 while the interaction rate is expected to be  $10^7$  per second. Clever selection of the events recorded from the total numbers of interactions is needed to enrich the B events recorded onto magnetic tape for off-line reconstruction. In the SFT experiment event selection occurs in several stages during data accumulation and relies on the decay characteristics of the beauty particles. The first is the inclusive decay of the B meson into the  $J/\psi$  meson. The branching ratio of  $B \rightarrow J/\psi + X$  has been measured to be 1.13%.<sup>8</sup> The  $J/\psi$  decays nearly instantaneously, so any  $J/\psi$  found to be downstream of the production vertex is an unambiguous signature of a B decay. One of the decay modes of the  $J/\psi$  is into a dimuon pair ( $\mu^+\mu^-$ ) which has a branching ratio of about 7%, yielding a total branching ratio of  $B \rightarrow J/\psi + X \rightarrow \mu^+\mu^- + X$  of  $7.9 \times 10^{-4}$ . The decay of a B meson into  $\mu^+\mu^-$  pair via the  $J/\psi$  particle is rare, but easily detected making this an effective trigger. Another important decay mode that will be used to trigger on B meson decays is the inclusive semi-leptonic decay:  $B \rightarrow \mu + X$ , which has a large branching ratio of 11%.<sup>4,9</sup> These decay modes were selected because high energy muons are easily separated from the hadrons produced in the primary interaction: they penetrate large quantities of matter such as steel or concrete.

The on-line electronic trigger is designed to detect dimuon pairs resulting from  $J/\psi$  decay or single  $\mu$ 's from the semi-leptonic B decay. The trigger must be able to discriminate muons produced by single muon decay and the  $J/\psi$  decay of B mesons from the much larger background sources. Considerable monte carlo studies were made of events generated with the Pythia monte carlo package of muons produced by B mesons and other background sources.<sup>10</sup> Figure 2 shows a plot of the angle of muons vs the muon momentum. A contour of constant  $P_T = 1.5$  GeV/c (transverse momentum) is superimposed on the plot. From the Figure it is seen that most of the background muons (produced by  $\pi$ , k, or D decay) have a  $P_T$  less than 1.5 GeV/c. We find that 18% of muons originating from  $B \rightarrow \mu + X$  have  $P_T > 1.5$  GeV/c and 33% of muons from  $B \rightarrow J/\psi + X \rightarrow \mu^+\mu^- + X$  have  $P_T > 1.5$  GeV/c and are accepted. The single muon decay trigger will trigger on muons with  $P_T > 1.5$  GeV/c and the  $J/\psi$  decay will trigger on events with a muon with  $P_T > 1.5$  GeV/c and a second muon in the event. The background rejection for this trigger is approximately  $10^4$ .

The leading candidate technique for beam extraction is crystal channeling. The nuclei in the ordered array of atoms in the crystal direct or channel positively charged particles traveling through the crystal down paths between the atoms. For bent crystals the particles follow the curvature of the path if the radius of curvature is not too severe. Some of the particles are lost or dechanneled because of multiple scattering, misalignment of the individual beam particle's momentum vector with the crystal plane, or interactions due to the cross sectional area of the crystal's nuclei. monte carlo simulations indicate that 34% of the protons will be dechanneled, with only 2% of the beam interacting. Most dechanneled protons are contained in the accelerator ring and can be channeled on subsequent passes. This results in an



## Fixed target experiment at the superconducting super collider

overall channeling efficiency of 85% for multiple passes. The bend angle required to extract some of the proton beam is only  $100 \mu\text{rad}$ , which calculations show is easily done.

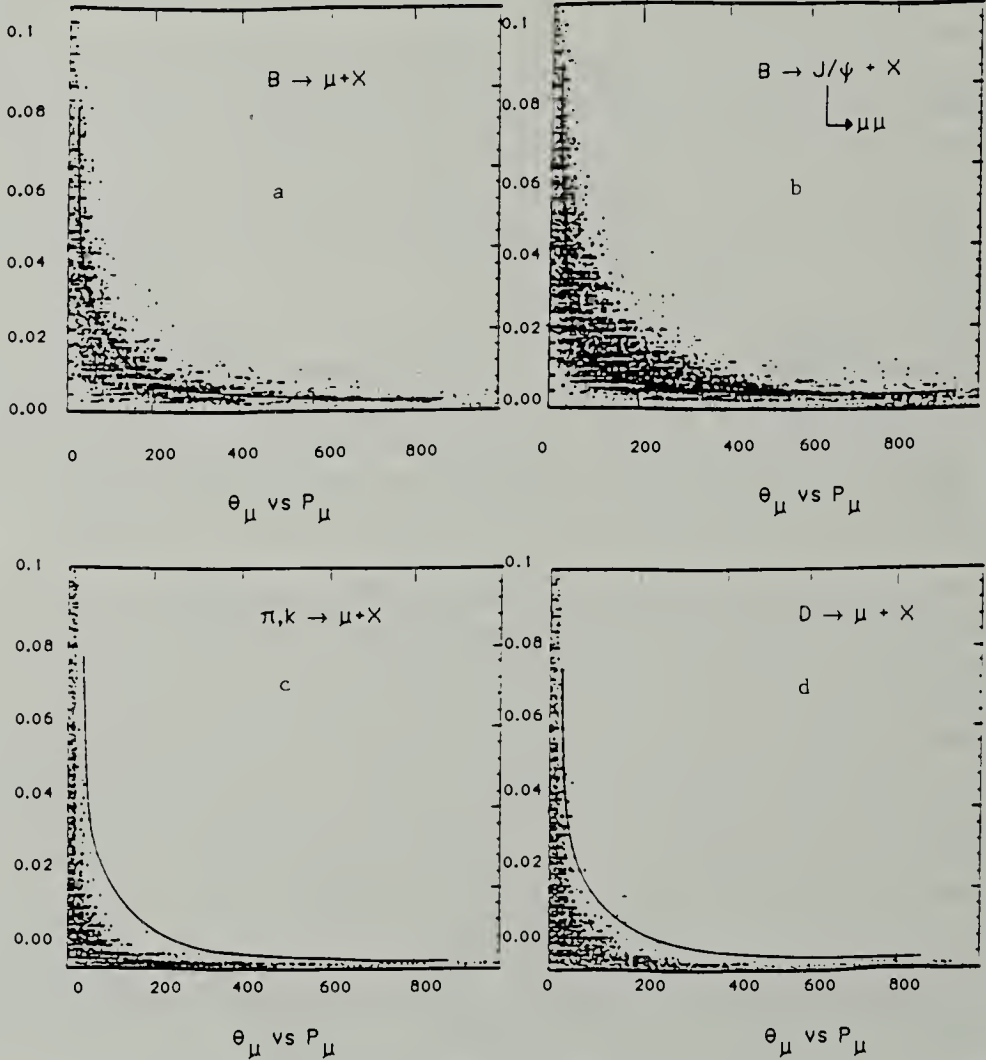


Figure 2. The momentum of muons produced from mesons decays is plotted vs the angle of the direction of the muon relative to the beam direction. Again events were generated by the Pythia monte carlo package for 20 TeV protons target. The line is a contour of constant transverse momentum of  $P_T = 1.5 \text{ GeV}/c$ . Figure 2a: momentum vs angle of muons produced from B meson single muon decay. 18% of these muons have  $P_T > 1.5 \text{ GeV}/c$ . Figure 2b: momentum vs angle of muons produced from  $B \rightarrow J/\psi + X$ ,  $J/\psi \rightarrow \mu^+ \mu^-$ . 33% of these decays have muons with  $P_T > 1.5 \text{ GeV}/c$ . Figure 2c: momentum vs angle of background muons produced by "regular" meson decay ( $\pi$  and  $k$ ). Note relatively few muons have  $P_T > 1.5 \text{ GeV}/c$ . Figure 2d: momentum vs angle for background muons produced from the D meson (which contains one charm quark). Again relatively few muons have  $P_T > 1.5 \text{ GeV}/c$ .

Figure 3 shows how the extraction works. First, the beam is expanded in the accelerator ring just before it encounters the crystal. A small portion of the outer part of the beam is then scraped against the crystal, in which the bend is in the upward direction (Figure 3b). The channeled protons are bent upward. The main accelerator beam and the channeled protons are separated in the vertical direction as they travel down a straight section (Figure 3a). At the end of the straight section the beams encounter a Lambertson string of magnets (Figure 3c). The unchanneled main beam is in a region of magnetic field and is bent back to the accelerator ring where it is contracted to its original size. The channeled beam is above in a magnetic-field-free region of the magnet's iron yoke and is unbent and continues on to the SFT experimental hall.

Figure 4 shows the SFT spectrometer, which is divided into several subsystems: charged particle tracking, particle identification, muon identification, and an electromagnetic detector (to detect high energy gamma rays and electrons).

The charged particle tracking subsystem will have small diameter proportional tubes (straw tubes), multi-wire proportional chambers interspersed between two momentum analysis magnets, and the silicon microvertex detector located near the target. The silicon microvertex detector (Figure 5) has 60 planes of silicon wafers, each 200  $\mu\text{m}$  thick. The target is constructed of 30 planes of 800  $\mu\text{m}$  Be foils sandwiched between 30 of the silicon tracker planes. The silicon strip detector planes are an array of diode strips etched onto a single silicon wafer. A current is produced in a single diode strip when a charged particle passes through it. The spacing between adjacent diode strips ranges from 25  $\mu\text{m}$  to 50  $\mu\text{m}$ . These silicon strip detectors are equivalent to multi-wire proportional chambers with 25  $\mu\text{m}$  to 50  $\mu\text{m}$  wire spacing. A spatial resolution between the primary interaction vertex and the secondary decay vertex of 600  $\mu\text{m}$  in the beam direction and 1.2  $\mu\text{m}$  in the transverse direction is expected with this system. This fine vertex resolution will enable the reconstruction of B mesons whose decay vertex is separated from the primary vertex by at least 6 mm along the beam direction and 60  $\mu\text{m}$  in the transverse direction.

Particle identification is made with a ring imaging Cherenkov counter. The diameter of the ring of Cherenkov light and the momentum of a particle is used to determine the mass of the particle; therefore identifying it. The electromagnetic calorimeter is split into two parts: one to measure the energy of shower from a high energy gamma ray or electron, the other to measure the position of the shower. From these measurements the momentum vector is calculated for gamma rays. Muon identification is accomplished by a series of three walls of steel shielding and detectors. The total shielding will stop a muon with momentum of 19 GeV/c or less in the central region, and muons with momentum of 15 GeV/c in the outer regions. Behind each wall is a plane of resistive plate counters. Each resistive plate counter is subdivided internally into a number of small pads that detect the location of the avalanche initiated by a charge particle passing through the chamber. Towers

Fixed target experiment at the superconducting super collider

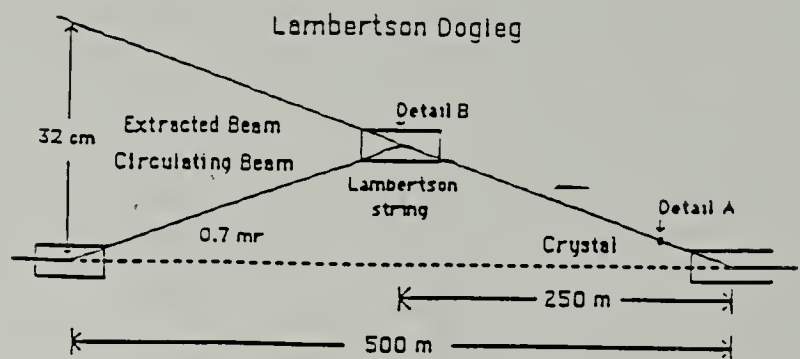


FIGURE 3A

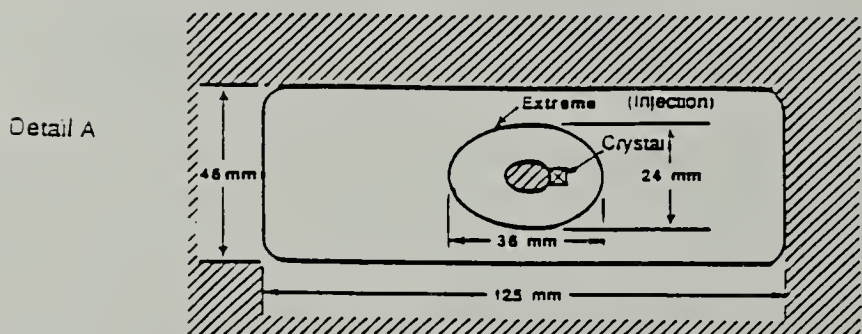


FIGURE 3B

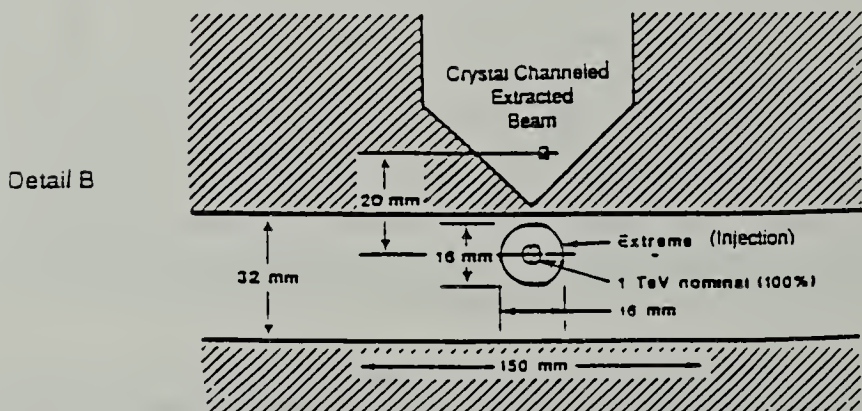


Figure 3. Schematic for crystal channeling extraction. Figure 3a: View from above the extraction string. The beam circulates from the right to left. The crystal is located left of the first string of magnets that bends the beam outward. Figure 3b: shows the beam just scraping the crystal along the beam direction. Figure 3c: shows the proton beam separated at two parts at the Lambertson string along the beam direction. The lower beam contains most of the protons and is bent back into the accelerator ring. The upper beam is in the magnetic field free region of the Lambertson magnet and is unbent.



SSC Super Fixed Target Beauty Spectrometer  
SFT

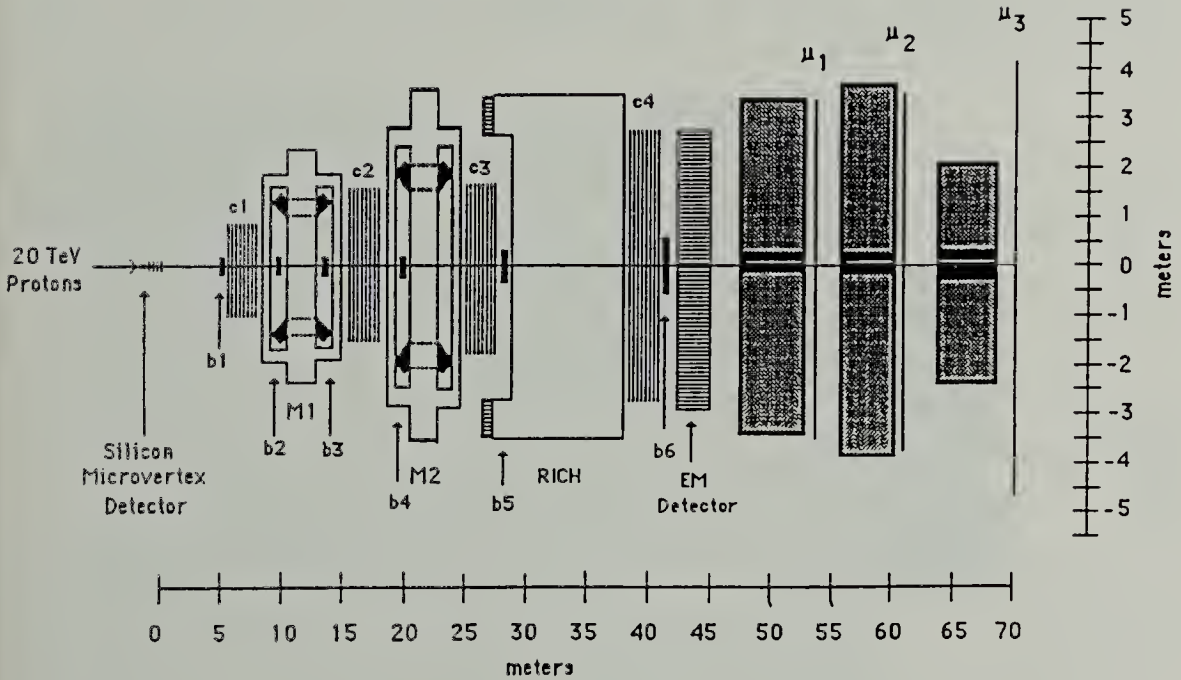


Figure 4. Schematic of the Super Fixed Target (SFT) spectrometer from above. The 20 TeV/c proton beam is directed from left to right. The beam interacts in the target producing the events to be studied. The target region contains the silicon strip detectors which emulate super-fine resolution wire chambers. The charged tracking subsystem includes silicon microvertex detector, small diameter proportional tube or straw tube chambers (c1 through c4), fine resolution multi-wire proportional chambers (b1 through b6), and two momentum analysis magnets (M1 and M2). The Ring Imaging Cherenkov Counter (RICH) is for particle identification. The electromagnetic calorimeter (EM Detector) measures the energy and position of electrons and high energy gamma rays. The muon detector ( $\mu_1$ ,  $\mu_2$ , and  $\mu_3$ ) is composed of three walls of steel with charged particle detection. It is located at the extreme downstream end of the spectrometer. Most other particles produced in the interaction will not penetrate all of the steel while muons will. The design is similar to many present fixed target experiments except for the length along the beam direction that has been increased for the larger beam energy.

# Fixed target experiment at the superconducting super collider

## SFT Silicon Microvertex Detector Schematic

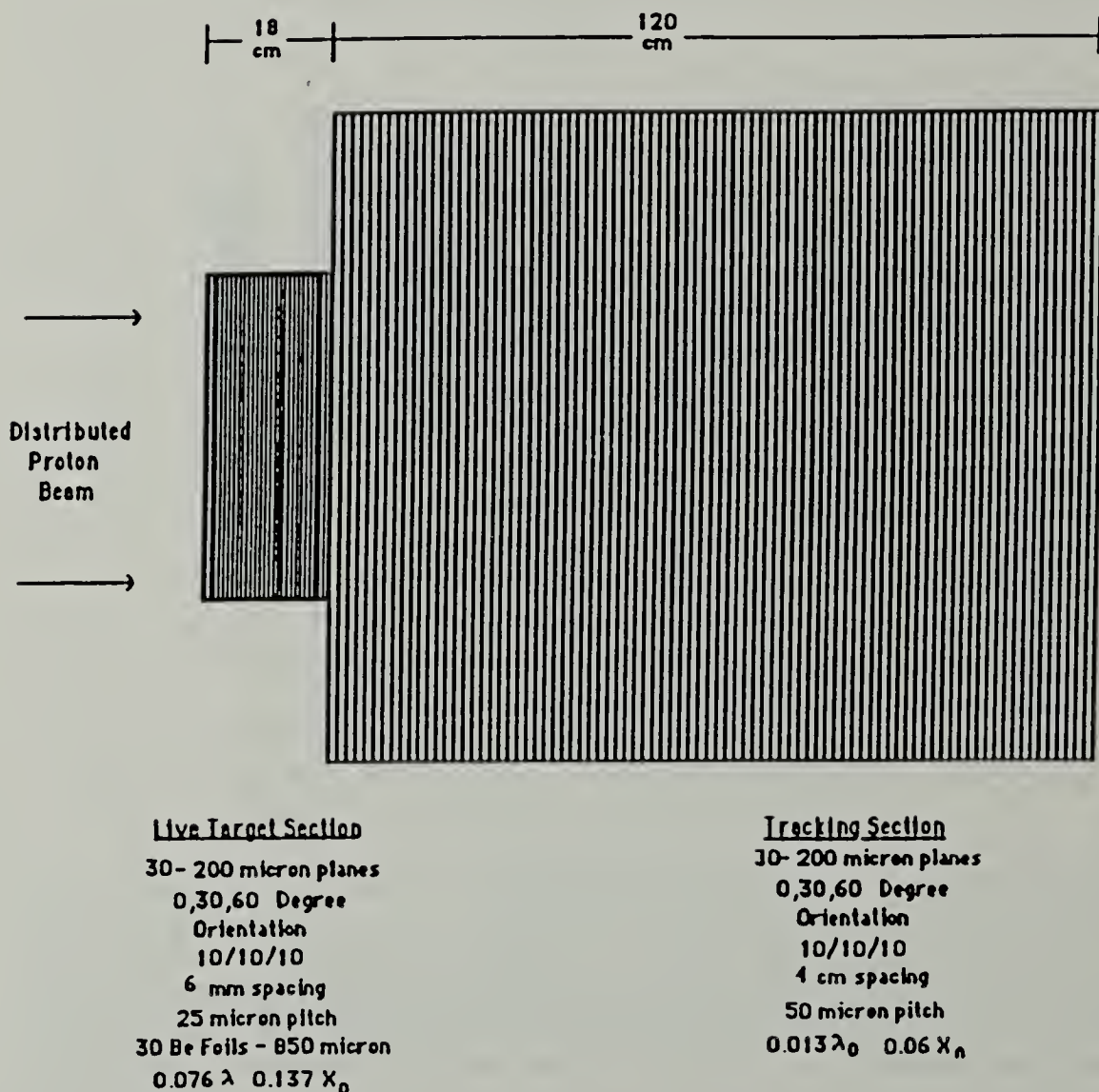


Figure 5. A more detailed view of the silicon microvertex detector. The silicon microvertex detector is constructed with 60 planes of silicon strip detectors. The first part of the detector alternates with a silicon strip detector then a Be foil 30 times. This forms the "live target" region of the detector and is 18 cm along the beam direction. Downstream is another 30 silicon strip detectors spaced over 120 cm. The individual strips in the silicon strip detectors will be oriented vertically (X planes), horizontally (Y planes), and at  $30^\circ$  and  $60^\circ$  (U and V planes) to the horizontal.

of pads from the three planes that project a trajectory of a muon originating from the production target with a  $P_T$  greater than 1.5 GeV are used to form coincidences for the lowest level trigger.

The overall geometric acceptance of the spectrometer for the B decays:  $B \rightarrow D e \nu$ ,  $B \rightarrow J/\psi K_{\text{short}}$ ,  $B \rightarrow J/\psi K_{\text{short}} \pi$  are: 70% for one B meson secondaries contained in the spectrometer, and 45% for two B meson secondaries from the  $J/\psi$  decay contained in the spectrometer.

A calculation may be made to determine if enough B mesons can be reconstructed and tagged to detect CP violation effects to a desired number of standard deviations. Table II give the estimate of totally reconstructed and tagged

Table II

$$B^0_d \rightarrow J/\psi K^0_{\text{short}}$$

$$J/\psi \rightarrow \mu^+ \mu^-$$

$$K^0_{\text{short}} \rightarrow \pi^+ \pi^-$$

Condition Imposed	Event Sample
$B \bar{B}$ produced	$1.3 \times 10^{10}$ to $5.2 \times 10^{10}$
$B \rightarrow J/\psi \rightarrow \mu^+ \mu^-$ ( $7.7 \times 10^{-4}$ )	$2.0 \times 10^7$ to $8.0 \times 10^7$
Trigger Acceptance (33%)	$0.66 \times 10^7$ to $2.6 \times 10^7$
Probability of a b quark combining with a u quark to form a $B_d$ (40%)	$0.26 \times 10^7$ to $1.1 \times 10^7$
$B_d \rightarrow J/\psi K^0_{\text{short}}$ (5% of $B_d \rightarrow J/\psi + X$ )	$1.4 \times 10^5$ to $5.6 \times 10^5$
$K^0_{\text{short}} \rightarrow \pi^+ \pi^-$ (69%)	$1.0 \times 10^5$ to $4.0 \times 10^5$
$K^0_{\text{short}}$ decay products contained in spectrometer (42%)	$0.42 \times 10^5$ to $1.7 \times 10^5$
$B \rightarrow J/\psi K^0_{\text{short}}$ Track reconstruction efficiency (90%)	$0.28 \times 10^5$ to $1.1 \times 10^5$
"Other" B decay track contained in spectrometer (65%)	$1.8 \times 10^4$ to $7.2 \times 10^4$
Probability of the other b quark combining with a u quark form a charged $B_u$ (40%)	$0.7 \times 10^4$ to $2.8 \times 10^4$
Efficiency of determining the $B_u$ charge (50%)	$0.34 \times 10^4$ to $1.4 \times 10^4$



## Fixed target experiment at the superconducting super collider

(particle and antiparticle)  $B_d^0 \rightarrow J/\psi K_{\text{short}}^0$  in one year (where  $J/\psi \rightarrow \mu^+ \mu^-$  and  $K_{\text{short}}^0 \rightarrow \mu^+ \mu^-$ ). The table starts with the number of  $B^0$  expected to be produced in one year of SSC data taking. This number of  $B^0$  is reduced by the various efficiencies to yield total of  $0.34 \times 10^4$  to  $1.4 \times 10^4$  fully reconstructed and tagged  $B_d^0$ . The CP violation of this decay is measured by an asymmetry calculated by integrating over one half period of oscillation the sum and differences of the time distributions (given earlier) for particle and anti-particle decay into CP eigenstates. The asymmetry becomes:

$$A = \frac{(N - \bar{N})}{(N + \bar{N})} = \lambda \frac{(\Delta m/\gamma) \frac{1 + e^{-(\gamma\tau/\Delta m)}}{(1 + (\Delta m/\gamma)^2) \frac{1 - e^{-(\gamma\tau/\Delta m)}}{2}}}{(1 + (\Delta m/\gamma)^2) \frac{1 - e^{-(\gamma\tau/\Delta m)}}{2}}$$

Using the experimentally measured value of 0.78 for  $\Delta m/\gamma^{11}$ , the asymmetry expected is  $A = 0.5\lambda$ . Choosing  $\lambda = 0.3$  yields an asymmetry of 15%. The number of events needed to produce a three standard deviation CP violation effect is:

$$N = (n\sigma/A)^2 = (3/0.15)^2 \approx 400 \text{ fully reconstructed events}$$

So 200  $B^0$  and 200  $\bar{B}^0$  fully reconstructed and tagged events are required to observe a three standard deviation CP violating effect in the channel:  $B_d^0 \rightarrow J/\psi K_{\text{short}}^0$  (where  $J/\psi \rightarrow \mu^+ \mu^-$  and  $K_{\text{short}}^0 \rightarrow \pi^+ \pi^-$ ) where the asymmetry is 0.3. This is well within the projected number of events to be reconstructed from one year of SSC data accumulation.

## SUMMARY

This experiment is unique because it is a fixed target experiment proposed to run at a colliding beam accelerator. The fixed target configuration will not have as many raw B mesons produced as the collider experiments, but should yield more reconstructed B mesons. A large number of events with one beauty particle fully reconstructed and the other identified is needed to detect CP violation. If CP violation exists in the B meson system at levels currently expected, then these CP violating effects should be observed by the SFT. Studying CP violation in the B system is important as this is the only other system besides the  $K^0$  system where it may be studied to give clues to its origin.

## ACKNOWLEDGEMENTS

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LITERATURE CITED

- <sup>2</sup>This collaboration has 36 institutions and about 140 Ph.D. physicist. To save space only the institutions are listed.
- <sup>3</sup>S. E. Anassontzis et al., "An Expression of Interest in a Super Fixed Target Beauty Facility (SFT) at the Superconducting Super Collider" May 25, 1990.
- <sup>4</sup>Particle Data Group, Physics Lett. B239 (1990).
- <sup>5</sup>I. Dunietz et al., Phys. Rev. D34, 1404 (1986).
- <sup>6</sup>David Griffiths, "Introduction to Elementary Particles" (New York, NY: John Wiley and Sons, 1987) Pp. 122-135.
- Donald Perkins, "Introduction to High Energy Physics" 3rd Ed. (Reading, MA: Addison-Wesley, Inc. 1987) Pp. 240-253.
- <sup>7</sup>B. Cox, "Experimental Possibilities for Observing CP Violation in B Decay" Fermilab-Conf-88/33, February 1988.
- <sup>8</sup>H. Albrecht et al., Phys. Lett. 162B, 395 (1985).  
P. Hass et al., Phys. Rev. Lett 55, 1248 (1985).
- <sup>9</sup>P. Albrecht et al., Phys. Lett. 197B, 452 (1987).
- <sup>10</sup>H. U. Bengtsson and G. Ingelman, Computer Phys. Comm. 34 351 (1985).
- <sup>11</sup>M. Artuso et al., Phys. Rev. Lett. 62, 2233 (1989).
- <sup>12</sup>T. D. Lee and C. N. Yang, Phys. Rev. 104, 254 (1956).
- <sup>13</sup>J. H. Christenson et al., Phys. Rev. Lett. 13, 138 (1964).





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**COVER PHOTOGRAPHS:** President's Mansion on the campus of the University of Alabama, Tuscaloosa, site of the 69th Annual Meeting of the Alabama Academy of Science, April 15-18, 1992.

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## ABSTRACTS

Papers presented at the 69th Annual Meeting  
The University of Alabama  
Tuscaloosa, Alabama  
April 15-18, 1992

### BIOLOGICAL SCIENCES

POPULATION ANALYSIS OF STERNOTHERUS MINOR PELTIFER. Craig Guyer, Dept. of Zoology, Auburn Univ., Auburn Univ., AL 36849. Karan A. Herndon, 702 Olinger Rd., Scottsboro, AL 35768.

This study was an attempt to determine a population estimation, sex ratio and age distribution of the strip-necked musk turtle, Sternotherus minor peltifer. Data was taken on 139 turtles from an estimated 200 by 400 yard site on the Tallapoosa River, Tallapoosa County, Alabama. The number of individuals in this population was estimated, by mark and recapture methods, to be approximately 700 individuals. The sex ratio was 45% males to 55% females. The age distribution, estimated by counting growth rings and measuring carapace lengths, indicated a balanced population of young to old individuals.

These results indicate that this particular population of S. minor peltifer at the Griffith Shoals of the Tallapoosa River is healthy and at carrying capacity.

INDUCTION OF ACROSOME REACTIONS IN HUMAN SPERM BY CROSSLINKING TRYPSIN INHIBITOR BINDING SITES. H. L. Boettger-Tong, D.J. Aarons, B.E. Biegler, T.A. Lee and G.R. Poirier. Department of Biology, University of Alabama at Birmingham, Birmingham, AL 35294.

Proteinase inhibitors are present on the various glands, tissues and secretions of the male reproductive tract. Some of these inhibitors bind to the acrosomal cap region of the sperm and their release during in vitro or in utero incubation suggests they may play a role in capacitation. In the mouse the binding site for a trypsin-acrosin inhibitor, the acceptor, has been implicated in zona binding and the acrosome reaction. This presentation demonstrates that a 20 kDa component on the human sperm head recognizes the murine inhibitor. Furthermore, the acrosome reaction can be induced in these cells by immuno-crosslinking the bound murine inhibitor. The data indicate that proteinase inhibitor binding sites on human sperm head, like a similar site on murine sperm, may play a role in the acrosome reaction.



## Abstracts

### INTER AND INTRA-SITE COMPARISONS OF THE DEMERSAL ICHTHYOFAUNA AT THREE SITES IN THE CENTRAL NORTHEASTERN GULF OF MEXICO.

L.E. Thompson, B.R. Kuhajda, and T.S. Hopkins

Five cruises were made aboard the R/V A.E. Verrill, Dauphin Island Sea Lab, Dauphin Island, Alabama, to three sites in the central north-eastern Gulf of Mexico. Station A is an area of which the episubstrate consists of anthropogenic structures (home appliances and tires; artificial reef), low rocky outcrops, and patchy sediment distribution over a relatively flat bottom at a depth of approximately 30m. Station B is an area of which the episubstrate consists of rhodoliths ranging in size from 5 to 10cm in diameter and is at a depth of approximately 85m. Station C is a biologically active substrate (live-bottom) and is at a depth of approximately 85m. Upon examination of principle components analysis plots using both seasonal and individual collections data (N, S', H', J', surface water temperature, bottom water temperature, surface salinity, and bottom salinity), general groupings could be seen although none of these were distinct. In comparing the seasonal species diversity through the use of a 2-way ANOVA, significant differences were found to only exist between stations ( $p < 0.05$ ). Through the use of a t-test on the species diversity, it was determined that Station A is the most diverse, Station B is intermediate in diversity, and Station C is the least diverse. No significant differences were found to exist between seasons or within stations. Through the use of average linkage cluster analysis with the Jaccard coefficient of community similarity, it can be seen that both individual and seasonal collection dates are grouped as being most similar to collections only from the same station. The Demersal ichthyofauna at these sites appear to be representative of both the Carolinian and the Caribbean-eurythermic faunas.

### THE CAHABA RIVER: VALUES, ISSUES AND INITIATIVES. Donald R. Elder, Cahaba River Society, 2717 7th Avenue South, Suite 207.

The Cahaba River is widely regarded as one of Alabama's most important and most threatened natural resources. The Cahaba River Society is a three and one-half year old organization working to protect the river's water quality, biological diversity, and scenic value. Don Elder, Executive Director of the Society, will report on the Society's programs in the fields of conservation, education, and recreation. He will give special emphasis to its initiatives to form a long range comprehensive plan for conservation and development in the urbanizing Upper Cahaba Basin and to improve state water quality policies and classifications.

## Abstracts

SPECIES COMPARISONS OF THE AUSTRALIAN AND AMERICAN CRAYFISH USING MOLECULAR WEIGHT PROTEIN AND IEF FINGERPRINTS. Mickie Powell, Mark Meade, George Cline, Stephen Watts, Dept. of Biology, Univ. of Ala. at Birmingham. Birmingham, AL 35294. and David Rouse, Dept. of Fisheries and Allied Aquacultures, Auburn Univ., Auburn, AL 36849.

In natural and hatchery populations, species identification of crayfish, particularly juveniles, is difficult. Identification of crayfish species using protein profiles generated by SDS polyacrylamide gel electrophoresis and isoelectric focusing (IEF) may allow identification of crayfish, even at very young ages. In the present study, sample extracts of total proteins were prepared from the tail muscle of adult Australian crayfish Cherax quadricarinatus, and local crayfish species in the genres Cambarus and Procambarus. The protein extracts for molecular weight determination were prepared by homogenizing tail muscle in 1% SDS and centrifuging to remove particulate. The supernatant was then made to 2% SDS and reduced using 2-mercapto-ethanol. Separation of the protein extracts using 5-20% gradient polyacrylamide gels showed many bands common to all species. However, C. quadricarinatus exhibited a triplet of bands between 80,000 and 90,000 daltons not seen in any of the other crayfish. All tissue sample extracts for IEF were homogenized in a 10 M urea solution and centrifuged. The supernatant was collected and focused on agarose and immobililine gels over the pH range of 4-7. Several major protein bands in the acidic pI range of 4.2 to 4.4 were present only in C. quadricarinatus and were absent in local crayfish species. Several major proteins in the pI range of 4.4 to 4.6 present in local crayfish were absent in C. quadricarinatus. These protein profiles may serve as species-specific markers to identify animals.

Chemical and Structural Defenses in the Soft Coral, Neospongododes sp. Marc Slattery<sup>1</sup>, James B. McClintock<sup>1</sup>, & Tom S. Hopkins<sup>2</sup>. Dept. of Biology, Univ. of Alabama at Birmingham<sup>1</sup>; and Marine Environmental Sciences Consortium, Dauphin Island, Alabama<sup>2</sup>.

The soft coral Neospongododes sp., from the coast of Alabama, utilizes chemical and structural defenses to ward off potential predators. Body tissues are comprised of protein (1.9% soluble, 11.1% insoluble), lipid (2.6%), carbohydrates (0.4%), and ash (84.0%). Cytotoxicity assays, using the sea urchin, Eucidaris tribuloides suggest Neospongododes sp. is chemically defended. Feeding deterrence assays suggest that high concentrations of spicules prevent grazing by the ecologically relevant butterfly fish, Chaetodon aya. Furthermore, an organic extract of the soft coral also deterred feeding by the butterfly fish. The energetic cost of producing both chemical and structural defenses may be warranted in response to the number of soft coral predators and their feeding strategies. Supported by AAS student research grant and NSF EPSCoR grant #R11-8996152.



## Abstracts

OXIDATION/REDUCTION STATE OF MITOCHONDRIAL CYTOCHROMES IN EXCISED BLUE CRAB GILLS: A SPECTROPHOTOMETRIC STUDY. Sabine C. Piller, J. E. Doeller, and D. W. Kraus, University of Alabama at Birmingham, AL 35294

Oxidative phosphorylation is the process by which cells use oxygen to generate chemical energy. Electron transport in oxidative phosphorylation is carried out by a number of electron-carrying proteins, including the cytochromes. The cytochromes are located on the inner mitochondrial membrane. Their oxidized and reduced forms show characteristic absorption spectra, allowing their behavior to be monitored spectrophotometrically. The gills of blue crabs, in addition to functioning in gas exchange, possess mitochondria-rich cells important for ionic and osmotic regulation. Stressful conditions increase the energy demand of the cell and alter mitochondrial activity. The oxidation/reduction state of mitochondrial cytochromes in excised blue crab gills was monitored with in vivo spectrophotometry under conditions of low oxygen stress and salinity stress. Intact living gills from specimens acclimated to different salinities were equilibrated to different levels of oxygen while mitochondrial spectra were recorded in situ simultaneously using a Cary 14DS spectrophotometer. From the optical difference spectra we have identified cytochrome oxidase, cytochrome *c*, and cytochrome *b*. The redox state of the individual mitochondrial cytochromes was determined as a function of oxygen partial pressure, and the partial pressure at 50% oxidation was calculated. Results show clearly that mitochondrial function is maintained for several hours after excision. In addition, mitochondrial state may change under different salinity and low oxygen stresses. Further investigation, including measurements of ATP content and oxygen consumption of the gills, will help to gain better understanding of the complex physiological processes occurring in gill tissue under stressful conditions. This study was supported in part by a grant from the Austrian Ministry of Science and Research to S. Piller

SEASONAL VARIATION IN THE DIETARY HABITS OF THE NINE-BANDED ARMADILLO (DASYPUS NOVEMCINCTUS) IN SOUTHERN ALABAMA AND SURROUNDING AREA. Lisa L. White and David H. Nelson, Dept. of Biology, University of South Alabama, Mobile, AL 36688.

Specimens of the nine-banded armadillo (Dasypus novemcinctus) were obtained by various methods over a two-year period (Fall 1989 - Summer 1991). A total of 151 individuals were collected from 13 counties in southern Alabama, Mississippi, and Florida. Specimens were sexed, measured, weighed, and dissected. Internal parasites were noted, and major internal organs were removed. The contents of the stomach and cecum were examined to determine dietary habits. Analysis of gut contents revealed that armadillos are primarily insectivorous, with the following orders strongly represented: Coleoptera, Diptera, Hymenoptera, and Isoptera. Several species of vertebrates were also encountered. Further analysis will determine possible seasonal variations in the diet of the armadillo in southern Alabama.



## Abstracts

Structural characteristics of brood pouches of the antarctic spatangoid echinoid Abatus nimrodi. Gottfried O. Schinner and James B. McClintock, The University of Alabama at Birmingham, AL 35294.

The structural characteristics of brood pouches (marsupia) of Abatus nimrodi and A. shackletoni were examined by aid of SEM. Female A. nimrodi ( $L > 50\text{mm}$ ) have 4 petaloid brood pouches formed by aboral ambulacral plates. Anterior pouches were significantly larger than posterior brood pouches. Each marsupium may hold up to 30 lecithotrophic embryos and juveniles. Juveniles can be divided into a) those with a mean length of 2 mm with early development of external elements (spines and pedicellariae) and b) those with a mean length of 4 mm, equipped with fully developed external elements. Brood pouches contain 3 different types of spines and tubercles, and 2 different kinds of pedicellariae. Large cover spines ( $L = 3.6 \pm 0.9\text{ mm}$ ,  $n = 5$ ) have a distally enlarged spine shaft, which more than doubles the shaft width towards the tip of the spine. Small cove spines ( $L = 1.4 \pm 0.4\text{ mm}$ ;  $3.2 \pm 0.7\text{ mm}^2$ ,  $n = 6$ ) are distributed mostly along the lower edge of the brood pouch and are layered. Tubercles ( $1.3 \pm 0.7\text{ mm}^2$ ,  $n = 5$ ) are platform-shaped with asymmetrical crenulation. This ensures maximum flexibility to facilitate the release of juveniles. Brood pouch bottom spines ( $L = 1.0 \pm 0.3\text{ mm}$ ,  $n = 8$ ) have a slender, straight shaft with a distinct distal enlargement ("bulb-head") and occur in high densities ( $6.9 \pm 1.2\text{ mm}^2$ ,  $n = 8$ ). The spinal epidermal layer is extremely enlarged, forming a thick "cushion". Ophiocephalous pedicellariae are abundant throughout the brood pouch and may serve a cleaning function. Dentate pedicellariae occur both as 3-valved forms, common in echinoids, and with 2 jaws, unique in spatangoids. These may prevent brood pouches from becoming clogged with sediment and may also repel small organisms. Preliminary investigations of a smaller ( $L < 40\text{ mm}$ ) congener, A. shackletoni, revealed no significant difference in size between anterior and posterior brood pouches. Spine and tubercle density was significantly lower than in A. nimrodi. These differences may be related to sediment characteristics in their respective habitats. Supported by NSF EPSCoR Grant # R11-8996152 to J.B.M. and by Austrian Schrödinger Postdoctoral Scholarship J-0614 to G.O.S.

## HUMAN TUMOR CELLS KILLED BY ISOLATES OF NEOTROPICAL ARALIACEAE

Debra M. Moriarity, Stacy Condra, Robert O. Lawton, Department of Biological Sciences, Jin Huang and William N. Setzer, Department of Chemistry, The University of Alabama in Huntsville, Huntsville, AL 35899

Tropical plants of the ginseng family (Araliaceae) were collected from the Monteverde Cloud Forest Reserve, Costa Rica. Crude ethanol extracts of the leaves were tested for cytotoxic activity against a human hepatocellular carcinoma cell line, Hep G2 and against cultures of normal hepatocytes. Of the twelve crude extracts tested, six were found to be very toxic to the Hep G2 cells. Of these six, five also were toxic to the normal liver cells. The extract that was not toxic to the normal cells, from *Dendropanax arboreus*, was fractionated, the active fraction located and preliminary structural analysis performed.

## Abstracts

HYPEROSMOTIC DEPRESSION OF ORNITHINE DECARBOXYLASE ACTIVITY IN BRINE SHRIMP NAUPLII. Joel Gotvald, Joseph Amato, and Stephen A. Watts, Dept. of Biology, Univ. of Alabama at Birmingham, Birmingham, AL 35294. Raymond Henry, Dept. of Zoology, Auburn University, Auburn, AL 36849.

Previous studies have shown that the activity of ornithine decarboxylase (ODC), the rate-limiting enzyme in polyamine synthesis, is induced significantly during acute hypoosmotic stress, and that the diamine putrescine accumulates during this stress. In the present study, nauplii were exposed to acute hyperosmotic conditions and ODC activity was determined. Cysts of the brine shrimp Artemia franciscana (SFB brand) were hatched and reared in 32 ppt artificial seawater for 24 hours, and these Stage I nauplii were transferred to control (32 ppt) or hyperosmotic media (50 ppt). The activity of ODC was assayed at various time intervals over a 24 hour period. Activity decreased from control values in hyperosmotically stressed shrimp within the first 10 min of exposure, remained depressed during the first 4 to 6 hours, and then returned to control values. The maximal decrease in activity occurred within 90 to 120 min. To determine the degree of stress necessary to depress activity, nauplii were hatched and reared in 12 ppt seawater for 22 hr, transferred to 12, 22, 32, or 50 ppt, and then assayed for ODC activity 2 hr later. These data showed that enzyme activity decreased with an increase in the degree of stress, with the maximal stress resulting in an approximate 60% depression in activity. We hypothesize that the decrease in ODC activity is related to an increase in the rate of degradation of the ODC protein, a decrease in synthesis, or a combination of both. These results suggest that significant interactions exist among hyperosmotic stress, ODC production, and polyamine synthesis. The exact mechanism of ODC depression and the fate of the polyamines are not known.

Geographic ranges and areas of intergradation between populations of eastern (Gambusia holbrooki) and western (G. affinis) mosquitofish. Robert A. Angus, Biology Dept., University of Alabama at Birmingham, Birmingham, AL 35294-1170. W. Mike Howell, Biology Dept., Samford University, Birmingham, AL 35209

The geographic ranges of the eastern and western mosquitofishes were investigated in the southeastern United States by counting dorsal and anal fin rays on preserved specimens from numerous sites. These fin ray meristic counts differentiate the two forms of mosquitofish quite well, although not absolutely. Geographic patterns of fin ray variation correlate well with those previously observed in studies of biochemical variation. Two areas of intergradation between the eastern and western mosquitofish have been identified. One area, in the vicinity of Mobile, Alabama has been known for many years. A more recently discovered area of overlap occurs further inland near Auburn, Alabama. A model of post-Pleistocene dispersal which might explain present distribution patterns will be discussed.



## Abstracts

POLYAMINE PROFILES MAY REFLECT GROWTH IN SHRIMP. Stephen A. Watts, Department of Biology, Univ. of Alabama at Birmingham, Birmingham, AL 35294, Shiao Y. Wang, Department of Biological Science, Univ. of Southern Mississippi, Hattiesburg, MS 39405.

The polyamine spermidine (SPD) and spermine (SP), and the diamine putrescine (PUT), are organic cations essential in many biological processes, particularly those associated with replication, transcription and protein synthesis. These molecules are currently being investigated as potential indicators of growth in several shrimp species, including the brine shrimp Artemia and Penaeus vannamei. In brine shrimp reared from stage I nauplii to three week old adults (24°C, 32 ppt salinity, fed 0.1 mg/ml/day Hatchfry Encapsulon), polyamine levels were determined during lag growth (day 6, 1.1 mm length), pre-exponential growth (day 10, 1.9 mm length) and during the exponential growth phase (day 13, 3 mm length). Polyamine levels were highest after hatching during stage I development, and then decreased during the first several days of development. PUT and SPD were the most prominent polyamines. PUT levels decreased, then increased during exponential growth; SPD levels increased throughout growth and SP levels decreased throughout growth. The ratio of SPD:SP increased during pre-exponential growth and was highest during exponential growth. Additionally, preliminary experiments indicate that the levels and ratios of polyamines may be altered in response to nutritional stress, leading to decreased growth rates. These data suggest that polyamine levels and ratios have utilization as biochemical indicators of growth in brine shrimp. Investigations are currently being conducted to determine their value as indicators of growth in commercially important penaeid species. This research is supported by Mississippi-Alabama Sea Grant Consortium, NOAA #NA 16RG0155-01.

A COMPARISON OF MORTALITY RATES DUE TO SHORT TERM WEATHER EVENTS ON A MIXED-SPECIES HERONRY OFF COASTAL ALABAMA. John I. Dindo and Ken R. Marion, Dauphin Island Sea Lab and University of Alabama at Birmingham, P.O. Box 369-370, Dauphin Island, AL 36528.

The population dynamics (clutch size, hatching success, and fledging success) of a mixed-species heronry on Cat Island, Alabama was examined from 1985 through 1988. A total of 1165 nests with 3339 eggs were marked and followed over the four-year period. During the entire study period the modal number of eggs for each species was three. Cattle Egrets laid smaller clutch sized than the other three species. Louisiana Herons, Snowy Egrets, and Little Blue Herons were predominately early nesters (March, April, May). Cattle Egrets established only 18 nests early and 167 nests late (June, July, August). Throughout the study period, Louisiana Herons, Snowy Egrets, and Little Blue Herons all hatched 75% or more of the eggs that they laid. Three-egg clutches had the highest success at hatching (84.3%). During the four-year study, survivorship to day 19 (fledge) was very high, with 71.2% of all eggs laid reaching the fledged stage. One hundred fifty-eight nests with eggs were abandoned during the early nesting season of 1988. During this time several days of rains and high winds were recorded. In 1976 following a rainy period with high winds Johnson and Gaston reported only 17% total survival. In 1985 a major hurricane hit after the breeding season. The storm reduced the available nesting sites for 1986, causing a decline in the overall breeding population during that year.



## Abstracts

CAVE SHRIMP OCCURRENCE IN NORTH ALABAMA. Stuart W. McGregor, Karen F. Rheams, and Paul H. Moser, Geological Survey of Alabama, P.O. Box 0, University Station, Tuscaloosa, AL. 35486.

The Alabama cave shrimp (*Palaemonias alabamae* Smalley) is one of only two known troglobitic shrimp in North America. It was discovered in a cave within the city limits of Huntsville in 1958, was described in 1961, and disappeared from that location in 1973. A second population was found in 1975 in a cave on Redstone Arsenal about eight miles southwest of the original location. The shrimp was recognized as an endangered species by the USFWS in 1988. In 1990 the USFWS contracted with the Geological Survey of Alabama to monitor the Redstone Arsenal population quarterly, to conduct tracer-dye studies in various areas to determine recharge areas of the caves known to contain shrimp, and to search other caves for new populations of the shrimp. In October, 1991, a new population of shrimp was found in a system of three hydrologically connected caves about 14 miles southeast of the original location. The new population is in an area geologically and hydrologically isolated from the previously known populations. This new find raises some interesting questions. The new cave system is known to have extremely high water velocities during the wet winter and spring months, but we assumed the shrimp prefers lentic, silt-bottom pools. Are these pools essential to the shrimp's life history, or has it only been seen in these pools because of its sessile nature and translucence? Is it much more common than we thought? Are geology and hydrology limiting factors? These questions could not be answered over one season, but we hope to shed more light on the life history requirements of the shrimp in the ensuing years.

ROLE OF TERMINAL  $\alpha$ -GALACTOSE RESIDUES IN SPERM-PROTEINASE INHIBITOR BINDING. Beth E. Biegler, David J. Aarons, Holly L. Boettger-Tong and Gary R. Poirier, Department of Biology, University of Alabama at Birmingham, Birmingham, AL 35294.

Murine sperm bind a proteinase inhibitor of seminal vesicle origin (SVI) at ejaculation. The inhibitor is removed during in utero or in vitro incubation enabling the inhibitor binding site to bind zona. It has been shown that a terminal  $\alpha$ -galactose residue on the ZP3 glycoprotein component of the zona pellucida is critical for sperm-zona binding. Since SVI and zona bind to the same site, it is the purpose of this study to determine if SVI is also a glycoprotein and if a terminal galactose residue participates in binding. Preliminary evidence indicates that SVI is a glycoprotein and a terminal  $\alpha$ -galactose residue has been tentatively identified. Removal of terminal galactose residues from SVI using an exogalactosidase does not cause a change in enzyme inhibitory activity or in molecular weight. However, preincubation of sperm with galactose has been shown to inhibit sperm-SVI binding in a concentration dependent manner as measured by indirect immunofluorescence and reduction of SVI-induced acrosome reactions. These observations suggest that a terminal  $\alpha$ -galactose residue on the SVI molecule is involved in binding to the sperm head.

## Abstracts

### ATTENUATION OF THE VASOCONSTRICTOR RESPONSE IN ELDERLY MEN.

Daniel Richardson, Dept. of Physiology and Biophysics, Univ. of Ky. Lexington, KY 40536. Julia Tyra and Jeanette Runquist Birmingham-Southern College, Birmingham, AL 35254.

The purpose of this study was to investigate the effects of age on the cutaneous vasoconstrictor response to cold stress. By placing the left arm in a cold water bath, 15°C, this effect was measured on the contralateral hand in two ways: 1) by video-microscopy techniques, which measured capillary blood velocity (CBV) in individual capillaries of the index finger, and 2) by laser Doppler flowmetry, which measured regional blood flow, velocity, and volume. If the vasoconstrictor response is inhibited by age, it would follow that blood flow and velocity in the older group would not change in the water bath. Ten young and ten elderly male subjects participated in this study. Three minutes of control data (out of the water bath) and five minutes of experimental data (in the water bath) were measured. Although both groups showed nearly equal reductions in LDF after the first experimental minute, the elderly group showed a subsequent increase in flow, possibly indicating a deficit in maintaining constriction. This deficit may be associated with the age related diminishment of  $\alpha_2$  adreno-receptors. These receptors, found in the cutaneous region, may be involved with increased sensitivity to norepinephrine in cold conditions. The young group's velocity (CBV) decreased in the first minute and remained at this lowered level, indicating a sustained vasoconstriction. The older group did not show a significant change.

### BIOLOGY OF THE AUSTRALIAN RED CLAW CRAYFISH, CHERAX QUADRICARINATUS.

Mark E. Meade, George B. Cline, and Stephen Watts. Univ. of Ala. at Birmingham, UAB Station, Birmingham, AL 35294.

The Australian parastacid decapods comprise over 100 species including some of the largest crayfish species in the world. Recently there has been considerable interest in the aquaculture of Australian crayfish in the U.S., especially of the genus Cherax. Three species of the genus Cherax have received substantial attention for potential culture, however, only the red claw, Cherax quadricarinatus, is presently considered a potential culture species in the southeastern U.S. Red claw are similar to our native American crayfish in their general anatomy, reproduction, and feeding preferences. There are, however, several differences between Australian and native crayfish which should be considered before intensive culture in the U.S. is initiated. Some of these differences include: 1) larger size, 2) multiple annual spawns, 3) higher fecundity, and 4) growth over a temperature range of 60 to 90°F. At the present time, several privately owned facilities are attempting to commercially culture red claw crayfish in Alabama. Nonetheless, optimal culture conditions for juvenile hatchlings have not been defined. We are currently examining the conditions which best suit the culture of hatchling red claw crayfish.

## Abstracts

DIFFERENTIAL TECHNIQUES FOR ANALYSIS OF STEROID METABOLISM IN TELEOSTS.  
Gene A. Hines and Stephen A. Watts. Dept. of Biology, Univ. of Alabama  
at Birmingham, Birmingham, AL 35294.

Experimental protocols for the determination of steroid metabolism in teleosts vary in their treatment of tissue preparations. We have compared different preparations of Tilapia niloticus including subcellular homogenates (cytosolic and microsomal preparations), crude homogenates, tissue minces, intact tissues, and a novel whole animal preparation via microaquaria. These preparations were incubated in the presence of radiolabeled androgen precursors ( $^3\text{H}$ -androstenedione and  $^3\text{H}$ -testosterone). Steroidal metabolites formed by enzymatic conversion of the radiolabeled precursors were extracted with methylene chloride and identified via thin layer chromatography, microchemical reactions, and recrystallization to constant specific activity. Relative amounts of radioactivity incorporated into each metabolite were determined using a Bioscan System 200 Imaging Scanner. Results indicated both qualitative and quantitative differences in steroid metabolism depending on tissue preparation. Subcellular fractions, crude homogenates and whole tissue preparations exhibited minimal capacities to convert precursors to other steroids. Tissue minces exhibited the highest rates of precursor conversion and product accumulation. In whole (live) preparations, the fry absorbed radiolabeled precursors from the media, converted them to multiple steroid products, and excreted some of the products back to the media as water-soluble steroid conjugates. These data indicate that the type of experimental preparation must be considered when evaluating steroid conversion rates, metabolic pathways or the fate of administered hormones.

DFMO INHIBITS ORNITHINE DECARBOXYLASE IN THE BRINE SHRIMP ARTEMIA.  
Stephen Powell and Stephen A. Watts. Dept. of Biology, Univ. of  
Alabama at Birmingham, Birmingham, AL 35294. Raymond Henry, Dept. of  
Zoology, Auburn Univ., Auburn, AL 36849.

a-Difluoromethylornithine (DFMO) is a suicide inhibitor specific to ornithine decarboxylase (ODC). Previous studies indicated that in 24 hr nauplii reared in 50 ppt artificial seawater (Tropic Marin) and then transferred to 50 ppt seawater in the presence or absence of DFMO, a significant increase in hydration occurred in animals exposed to 50 ppt + DFMO. This indicated a possible interaction between ion transport and polyamine metabolism. These studies indicated that the confounding influence of lowered pH in the solution containing DFMO may have resulted in altered hydration patterns. In the present study, the brine shrimp were hatched in 50 ppt seawater in the presence or absence of 1 mM DFMO. This time, however, the pH was adjusted in the 50 ppt + DFMO solution to 8.44 (the pH of the 50 ppt solution). When incubated under these conditions, there was no significant increase in hydration in individuals incubated in 50 ppt + DFMO as opposed to those incubated in 50 ppt. Furthermore, preliminary studies indicate that induction of ODC activity is dependent on the pH of the culture medium. These results indicate that an interaction exists among pH, ODC activity, and osmoregulation.



## Abstracts

NA<sup>+</sup>, K<sup>+</sup> ATPASE ACTIVITY IN DEVELOPING BRINE SHRIMP NAUPLII DURING OSMOTIC STRESS. Kara J. Lee and Stephen A. Watts, Dept. of Biology, Univ. of Alabama at Birmingham, Birmingham, Al. 35294.

The effect of salinity on ouabain-sensitive Na<sup>+</sup>, K<sup>+</sup> ATPase activity in Artemia embryos and nauplii was examined during normal development under constant salinity conditions. In shrimp reared from cysts in either 5, 12, 32, or 50 ppt seawater, enzyme activity was measured from 15 hrs (emergent stage) to 38 hrs (stage I/II nauplius) after the start of incubation. Na<sup>+</sup>, K<sup>+</sup> ATPase activity increased ca. 10 fold from 15 to 30 hours, regardless of the environmental salinity. The increase in Na<sup>+</sup>, K<sup>+</sup> ATPase activity can be blocked by the addition of cycloheximide, indicating that this increase is due to new synthesis of the enzyme. During emergence and early stage I development, increased activity may reflect an ontogenetic program of enzyme induction that is necessary for development of competent nauplii. However, during late stage I and perhaps in subsequent development, enzyme activity levels appear to be influenced by environmental salinity i.e., higher activity was observed at higher salinities. A time course of Na<sup>+</sup>, K<sup>+</sup> ATPase activity was also determined in early stage I nauplii after acute exposure to hypo- and hyperosmotic conditions. In nauplii raised in 50 ppt and then transferred to either 50 or 12 ppt, enzyme activity was lower in nauplii exposed to 12 ppt within 1 to 2 hours after transfer, but then continued to increase during subsequent development. Nauplii raised in 12 ppt and then transferred to 12 or 50 ppt did not have significantly different Na<sup>+</sup>, K<sup>+</sup> ATPase activity after 6 hours. These results suggest that in stage I nauplii, a developmental program of enzyme induction overrides any short term osmotic stress responses that might involve changes in total amount of enzyme. The quantity of Na<sup>+</sup>, K<sup>+</sup> ATPase may not be as important in short term regulatory responses to changes in water and ion content as it may be in long term ion and volume maintenance.

BLOCKAGE OF ZONAE INDUCED ACROSOME REACTIONS BY A PROTEINASE INHIBITOR OF SEMINAL VESICLE ORIGIN. David J. Aarons, Holly Boettger-Tong, Beth E. Biegler, and Gary R. Poirier. Department of Biology, University of Alabama at Birmingham, Birmingham, AL 35294.

Murine sperm bind a proteinase inhibitor of seminal vesicle origin at ejaculation. The inhibitor binds in the acrosome region, and is removed during in utero or in vitro incubation. Adding inhibitor to sperm reduces their ability to bind zonae. Adding the purified inhibitor binding site to oocytes reduces their ability to bind sperm. Immunoaggregation of inhibitor binding site results in exocytosis of the acrosome. These observations suggest that the inhibitor binding site may participate in zona binding and the acrosome reaction. If the inhibitor binding site binds both the zona and the seminal inhibitor, then these components should compete with each other for that site on the sperm. We show that purified seminal inhibitor, as well as other proteinase inhibitors block zonae induced acrosome reactions. Zonae glycopeptides block inhibitor-anti-inhibitor induced acrosome reactions in a concentration dependent fashion. The inhibitor-anti-inhibitor induced acrosome reaction is pertussis toxin and proteinase inhibitor sensitive and thus is similar to zonae induced reaction. These findings support the suggestion that the trypsin-inhibitor binding site on the head of the sperm functions to insure sperm binding and induction of the acrosome reaction.

## Abstracts

EFFECTS OF A UNIQUE ROTATING CULTURE SYSTEM ON PANCREATIC RELEASE. Rebecca Conway, Connie Meacham, Adriel D. Johnson and Marian L. Lewis, Dept. of Biological Sciences, Univ. of Alabama, Huntsville, AL 35899.

Pancreatic pieces ( $<1\text{mm}^3$ ) removed from 18d chick embryos were cultured in static flasks and horizontally rotating bioreactors (rotating culture system, RCS) which provide a low-shear culture environment similar to microgravity. The initial study on the effects of the RCS on pancreatic function was reported in the J. Alabama Academy of Science 62:74. In trial one, culture medium removed from the RCS and a static control flask at 0, 24, 48, and 72hr was evaluated for metabolic parameters and enzyme release. Histological examination revealed functional tissue at the end of the 72hr incubation period. Glucose in the medium decreased to  $<10\%$  of the initial concentration and amylase increased from 0 to  $1070\text{ U/L}$  (RCS) and from 0 to  $822\text{ U/L}$  (control) during the 72hr incubation period. In trial two, carbachol (cholinergic agonist) was added to the medium in one RCS vessel and amylase release and metabolic parameters over a 0-262h incubation period were compared to a second RCS vessel (without carbachol), and a static control flask. In the RCS with carbachol, amylase release was increased by 5-47% compared to the RCS without carbachol and the static control, respectively. These data indicate that pancreatic functions can be maintained, stimulated, and possibly enhanced in the low-shear altered gravity conditions of the RCS.

DISTRIBUTION OF THE PINE BARRENS TREEFROG, HYLA ANDERSONII, IN CONECUH NATIONAL FOREST, ALABAMA. John B. Jensen, Dept. of Zoology-Wildlife Science, Auburn University, Auburn, AL 36830.

Previous to this study, the Pine Barrens treefrog, Hyla andersonii, was known to occur at ten localities within Conecuh National Forest. During this study, the status of this frog species in the Forest was assessed from June through September 1991. Location of the frogs was accomplished by searching for suitable habitats by day, revisiting the sites at night, and listening for the distinct call of males or eliciting them to call by vocally imitating their call. Thirteen new localities were discovered and six previous localities maintained calling males. At four previously known localities males were never heard, indicating that they no longer support Hyla andersonii. Lack of fire at these four localities is suspected to be the reason the frog populations have disappeared.



## Abstracts

REPRODUCTION AND ECOLOGY OF THE BRITTLE STAR *ASTEROPORPA ANNULATA*. James B. McClintock, Ken R. Marion, Stephen A. Watts, Gottfried Schinner, Dept. of Biology, Univ. of Ala. at Birmingham, AL 35294. Thomas S. Hopkins, Dept. of Biology, Univ. of Ala., Tuscaloosa, AL 35486.

Histological examinations of the gonads of the deep water brittle star *Asteroporpa annulata* were conducted on a rhodolith substratum from October, 1988 to April, 1991 in the northern Gulf of Mexico. An annual synchronous gametogenic cycle was evident. Small vitellogenic oocytes (40-50 um diameter) were present in February. By April and May, vitellogenic oocytes had increased to 70-90 um diameter. Mature oocytes (130-160 um diameter) were evident in September, 1989 and in November of both 1990 and 1991. Testes also matured in the fall and early winter. Given the sizes of embryos produced, it is likely that reproduction is characterized by the release of larvae with abbreviated development. No embryos were detected in the bursae, ruling out a classical brooding mode. Several juvenile individuals were found grasping adults around the aboral disc, indicative perhaps of delayed brooding. Population size frequencies were static, with a mean disc diameter of 18.8 mm. Little evidence of significant recruitment of juveniles was observed. We propose that either recruitment occurs sporadically or that larvae settle in another area and migrate, as juveniles, into the study area. Supported by NSF EPSCoR grant #R11-8996152 (J.M., S.W., T.H. and K.M.) and by an Austrian Postdoctoral Fellowship #J-0614 (G.S.).

DISTRIBUTION OF THE GOPHER TORTOISE (*GOPHERUS POLYPHEMUS*) IN MOBILE COUNTY, ALABAMA. David Nelson, Suzie Hatten and Lisa White, University of South Alabama, Mobile, AL 36688; and Steve Carey, Mobile College, Mobile, AL 36613.

In order to assess the distribution of gopher tortoises within Mobile County, a systematic survey was conducted in the summer of 1991. In each non-wetland township, we surveyed available sites in which tortoises might be expected to occur. Both public and private lands were sampled. A line-transect burrow count system was employed; each burrow was measured and characterized as "active," "inactive" or "old." During 28 days in the field, we sampled a total of 392 burrows in 32 townships and drove a total of 2,642 miles; 173 burrows were encountered on a total of 67 transects. Forty of the 67 transects (60%) were found to contain at least 1 burrow; 27 (40%) of the transects revealed no burrows. Burrow densities were compared across habitat types and soil types. Preliminary data analysis indicates declining populations; tortoises have been extirpated from urban areas. Although populations continue to decline in the southern parts of the county, they appear to be comparatively more stable in elevated areas of north Mobile County, where the habitat has been less severely disturbed.



## Abstracts

MANAGEMENT OF WATER RESOURCES IN ALABAMA. Louis G. Williams, Emeritus Prof., Dept. of Biological Sciences, Univ. of Ala., Tuscaloosa, AL 35487.

The chemical, physical and biological characteristics of surface waters are interrelated phenomena. Making use of stream biota to determine existing, and to forecast future, water quality in a stream offers promising possibilities. For ten years I was in charge of the plankton program of the U. S. Public Health Service's National Water Quality Network. Semimonthly plankton samples were collected and analyzed from 65 widely scattered stations of the United States out of the 137 for a two-year period ending on June 30, 1961. All plankters were enumerated from special plankton counting chambers (Sedgwick Rafter) as in numbers per milliliter. Diatoms were identified using 1000X magnification using special lenses and special hyrax mounting medium. Diatoms were incinerated on a very thin cover glass on an electric hot plate. The thin cover glass with the incinerated diatoms and other associated detritus were mounted in hyrax so that only the glass cell walls remained. Classification is based only on markings of the cell walls, with each species having its unique markings. Diatoms were identified by using 1000X, but the cells were counted in a chamber using about 100X. This allowed enumeration to give the number per milliliter. However, the species identification used 1000 diameter magnification with apochromatic lenses in the microscopes and special hyrax medium on the glass slides from which species identification was determined, by cell wall markings only. However, green algae, blue-green algae and zooplankton were enumerated at 100X unless higher power was needed for identification to species. Excessive turbidity was washed out by adding water and decanting the turbidity to a workable level.

PHYLOGENETIC RELATIONSHIPS OF THE BOARFISHES (TELEOSTEI: FAMILY CAPROIDAE). Steven J. Zehren, Dept. of Cell Biology, Univ. of Ala. at Birmingham, Birmingham, AL. 35294.

An osteological study of the Caproidae (Capros, Antigonia, Microcapros) was made to ascertain its monophyly and intragroup relationships. Character polarity was determined by outgroup analyses. A computer program was used to generate cladograms (including a consensus tree). Monophyly of the Caproidae is supported by seven characters including ornament on the preopercle, frontal and supracleithrum. Antigonia is defined by scales w/denticulated ridges, pelvic bones w/small spinous processes, orbital curvature of the parasphenoid and 22 vertebrae. A. veronensis (Eocene) is the sister group of the other (living) species which share a deep coracoid process that fails to meet the cleithrum, a 1st dorsal pterygiophore that lies between both the halves of the 1st neural spine and exoccipital laminae and a supraoccipital crest that has ornament. Relationships among most living species of Antigonia are unclear. Microcapros (Cretaceous) + Capros form a clade defined by a highly ornamented opercle and ridges on the cleithrum. Although the monophyly of Capros is uncertain, C. aper (living) is most closely related to C. medianus (Oligocene) (ornament on the lateral ethmoid and only 22 vertebrae).

## Abstracts

POST-ENDOCYTIC PROCESSING OF VITELLIN POLYPEPTIDES IN OVARIAN FOLLICLES OF THE STICK INSECT CARAUSIUS MOROSUS Br. B. Estridge and J. Bradley, Dept. Zoology & Wildlife Sci., Auburn Univ., AL 36849. F. Giorgi, A. Cecchetti, M. Masetti, and V. Ignacchiti, Dept. Biomedicine, Univ. of Pisa, Italy 56100.

In oogenic insects, yolk proteins (vitellogenins) synthesized by the fat body are secreted into the hemolymph and sequestered as vitellins (Vn) in yolk spheres in the developing oocytes. *C. morosus* oocytes contain two immunologically distinct multimeric Vns, Vn A and Vn B (respective subunit compositions--A<sub>1</sub>:120 kD, A<sub>2</sub>:107 kD, A<sub>3</sub>:60 kD and B<sub>1</sub>:180 kD, B<sub>2</sub>:70 kD). Using native- and SDS-PAGE (1- and 2-dimensional), fluorography, immunoelectrophoresis, immunoblotting, and FPLC and HPLC analyses, we show that these Vns undergo several stage-specific, structural modifications during oocyte development prior to the onset of embryogenesis. These modifications include changes in the molecular weights of A<sub>1</sub> and A<sub>2</sub> upon endocytic transfer into the oocyte, a charge change in B<sub>1</sub> and proteolytic processing of A<sub>3</sub> after uptake by the oocyte, and changes in the relative amounts of monomeric and dimeric native Vn A and Vn B correlating with morphological changes in the yolk spheres. Preliminary evidence also suggests the presence of pH-dependent proteolytic activity in a 26 kD polypeptide present in several stages of vitellogenic oocytes. Results of this study suggest that Vn polypeptide processing in ovarian follicles of *C. morosus* may be a prerequisite for Vn aggregation into larger molecular forms. The functional significance of this may relate to the embryo's need to reduce osmotic pressure within the oocyte.

Supported by the Alabama NSF-EPSCoR Program in Molecular, Cellular and Developmental Biology (Grant #RII-8610669) and HATCH Project 665 (AAES).

A MORPHOMETRIC STUDY OF THE GUT IN THE ECHINOID LYTECHINUS VARIEGATUS. Charles D. Bishop and Stephen A. Watts, Dept. of Biology, University of Alabama at Birmingham, AL 35294

Previously starved *Lytechinus variegatus* were fed a 5% fish meal-agar diet and ad libitum for 32 days at 20°C and 32 ppt salinity. Morphometric analysis showed the mucosa of the stomach and intestine grew by hyperplastic and hypertrophic mechanisms. Mucosal fold height increased significantly, 83 and 39% respectively, in the stomach and intestine. The height of the mucosal depressions increased significantly (166%) in the stomach while the intestine showed an increase to day 8 (24%) then decreased to original levels. The height of the visceral peritoneum increased significantly in the stomach and intestine, 44 and 91% respectively. The stomach of starved individuals contained numerous depressions that decreased significantly (42%) in number per unit area during growth. Conversely, the number of depressions in the intestine significantly increased (53%). Concurrently, the mean fold width increased significantly (38%) in the stomach and decreased significantly (33%) in the intestine by day 8. These changes suggest an increased surface area in the intestine, possibly for increased absorption, while the stomach underwent a decrease in surface area, most probably due to the storage of digested organic material.

## Abstracts

GREENHOUSE GASES, ARE THEY CONTRIBUTING TO URBAN WARMING (HEAT ISLAND)  
Oskar M. Essenwanger, College of Science, University of Alabama in  
Huntsville, Huntsville, AL, 35899.

The so-called heat island effect is known for almost 150 years. It is attributed to the difference in the heat capacity by stone masses and roads in the city as compared with the groundcover in rural areas. Effects of greenhouse gases are considered to be negligible. This author analysed one year of data from the Huntsville, Al., area (Sept. 90 - Aug. 91) for an investigation whether greenhouse gases would contribute to urban warming. The urban temperature and pollution gases were measured by the Huntsville, Al, pollution office (hourly recordings). The rural data were taken from the Weather Bureau records at the airport, 20 miles west of the pollution measurement site. The temperature differences of the daily minimum and maximum between these two locations show the usual trend between urban and rural area. However, a surprisingly high correlation between CO level and the daily minimum temperature difference,  $r = \text{over } 0.5$ , for Oct. 90 through May 91 was disclosed. This coefficient is statistically significant at the 3 sigma level of confidence. No significant correlation was found for Sept. 90, June - Aug. 91. This trend conforms with the cycle of carbon dioxide whose level is low in summer. Thus no contribution may be expected in summer. The correlations for nitrogen dioxide parallel the one for CO but are lower.

In conclusion: Greenhouse gases could possibly add to the urban warming during certain months in the colder season. However, this study is only based on one year of data at one geographic location.

The author thanks the Huntsville, Al, pollution office for providing the pollution data for this study.

FOSSORIAL CRAYFISHES (DECAPODA:CAMBARIDAE) OF A SMALL RIVER BASIN IN CENTRAL ALABAMA. James V. Buchanan and J. F. Fitzpatrick, Jr., Dept. of Biology, Univ. of South AL., Mobile, AL 36688.

As members of the Arthropoda, crayfish belong to one of the largest, most successful and economically important groups of invertebrates. As presently known Alabama's crayfish fauna is the most diversified of any state, with 72 known species and several yet undescribed. Despite their large numbers, few systematic surveys of the crayfishes of Alabama have been conducted. Ten genera of crayfishes occur in the southeastern United States; seven of these are represented by species within the borders of Alabama: *Cambarellus*, *Cambarus*, *Fallicambarus*, *Faxonella*, *Hobbseus*, *Orconectes*, and *Procambarus*. An intensive survey of the burrowing crayfishes of the Cahaba River Basin is being undertaken with 200 localities surveyed since the summer of 1991. Centrally located within Alabama, the Cahaba River is one of only a few "wild rivers" in the eastern United States. Fossorial members of four genera have been found thus far: *Cambarus*, *Fallicambarus*, *Orconectes*, and *Procambarus*. The distribution of the various species encountered, their reproductive ecology, and their environmental conditions are presented. The majority of crayfishes were collected within the tributaries, rather than the river proper.



## Abstracts

PRACTICE MANAGEMENT PREPARATION DURING A FAMILY PRACTICE RESIDENCY. Pat Norton, George Tulli, and MinQi Wang, The University of Alabama School of Medicine--Tuscaloosa Program, Tuscaloosa, AL 35487.

Following a review of literature in practice management, a survey was developed in order to determine perceptions of practicing physicians regarding the importance of 35 items in running a successful practice. They were also asked to rate how well their medical education had prepared them to deal with these items. The survey was mailed out to the last 5 years' graduates (n=85) of the University of Alabama School of Medicine's Family Practice Residency Program, Tuscaloosa. A 57% response rate was attained. Thirty-three of the 35 items were rated as important or very important to a successful practice by more than 50% of the doctors. Of greatest importance were topics dealing with billing, fee structure, and third-party payers. Over half the doctors surveyed felt unprepared or very unprepared to deal with these topics. Also listed as important or very important by at least 86% of the doctors were issues in personnel management, with, again, over half the doctors feeling unprepared or very unprepared in this area. The responses to these surveys are being incorporated into a new, more structured family practice management curriculum. This study was supported by grant number 1-D15-PE14325-01 from the Dept. of Health & Human Services.

DISTRIBUTION AND POPULATION STRUCTURE OF *CALLINECTES SIMILIS* IN ESTUARINE AND COASTAL HABITATS OF ALABAMA. Pan-wen Hsueh and James B. McClintock. Dept. of Biology, University of Alabama, Birmingham, AL 35294. Tom S. Hopkins, Marine Environmental Sciences Consortium, Dauphin Island, AL 36528. Stevens R. Heath, Dept. of Conservation and Natural Resources, Dauphin Island, AL 36528.

Distribution and population structure of the lesser blue crab *Callinectes similis* in estuarine and coastal habitats of Alabama was investigated. Crabs were collected from 18 sampling stations, which are indicative of the three most common habitats (sandy beach, salt marsh and open-bay mud-bottom) occurring in Alabama coastal and estuarine waters. *Callinectes similis* appears to be widely distributed in Alabama estuarine and coastal habitats. Juvenile *C. similis* were collected from all three types of habitats, whereas large (> 30 mm CW) *C. similis* were not collected from salt marsh habitats. These results suggest that megalopae of *C. similis* settle in all three types of habitats. Juveniles either suffer predation in salt marshes or migrate to open-bay and sandy beach habitats as they grow. Although sample sizes collected from shallow habitats (marshes and sandy beaches) were small, male crabs dominated numerically. In open-bays, sex ratios were more equivalent.

## Abstracts

CHOLINERGIC EFFECTS ON PANCREATIC RELEASE IN THE EMBRYONIC CHICK. Connie Meacham, Lakshmi Reddy and Adriel D. Johnson, Dept. of Biological Sciences, Univ. of Alabama, Huntsville, AL 35899. Jacqueline U. Johnson, Dept. of Food Science and Animal Industries, Alabama A&M Univ., Normal, AL 35762.

Organ cultures were prepared using the pancreas from 18 day-old embryonic chicks to test the effects of cholinergic agonists on enzyme release. Four concentrations (.05mM, .5mM, 5mM, 50mM) of two synthetic parasympathomimetic agents, carbamylcholine chloride (carbachol), and bethanechol chloride were examined to determine the stimulatory effects on amylase release into the culture medium during a 4, 8, 16, and 24h incubation period. Carbachol concentrations of .5mM, 5mM, and 50mM stimulated amylase release up to 58% after 4h and 23% after 8h when compared to control cultures (without carbachol). No medium amylase increases occurred after 16h or 24h at any carbachol concentration. Bethanechol concentrations of .05mM, .5mM, 5mM, and 50mM stimulated amylase release during the 4h and 8h incubation periods, after 16h at .05mM, 5mM, and 50mM and after 24h at .05mM. These data indicate a regulatory role of muscarinic stimulation in chick embryonic pancreatic tissue during development and therefore, pancreatic function may be enhanced.

ASPECTS OF THE REPRODUCTIVE BIOLOGY OF *CYCLONAIAS TUBERCULATA* (UNIONIDAE:BIVALVIA). Thomas M. Haggerty, George P. Patterson, and Lannis C. Jones, Dept. of Biology, Univ. of North Alabama, Florence, AL.

Three hundred and fifty-two purple wartybacks (*Cyclonaias tuberculata*) were collected approximately monthly from Kentucky Lake, Tennessee, (TRM 201.3) over a three year period. Male shells tended to be significantly larger than females, but females were significantly wider than males of the same length. A 1:1 sex ratio and only one case of hermaphroditism were discovered. Histological examinations showed that spermatogenesis and oogenesis occurred throughout the year except during late summer early fall. "Typical" spermatogenesis was most evident between May and July. Gametes passed out of gonad follicles between early spring(March/April) and late summer(August). Variation in female reproductive habits was shown by embryos in suprabranchial chambers and gills between early April to late August. Brooding was short-term as indicated by larvae being found in the outer demibranchs between early July to late August. Full demibranchs were never found possibly indicating that our study took place during years of poor reproductive performance and/or that larvae are released gradually rather than at one time.



## Abstracts

NEST BOX USE BY SOUTHERN FLYING SQUIRRELS (*Glaucomys volans*) IN ALABAMA. Suzie Hatten and David Nelson, Department of Biology, Univ. of South Ala., Mobile, AL 36688.

One hundred nest boxes were installed on trees in a 25 X 25-m grid. In addition, 69 live-traps were wired to trees in a 25 X 25-m grid within the nest box grid, such that each trap was centered within 4 nest boxes. The nest boxes were checked bimonthly, and trapping was conducted for 5 consecutive days at the end of each month. From June 1991 to February 1992, 60 squirrels were captured 343 times. Thirty-five of these (59%) were captured in both nest boxes and traps. Twenty-three squirrels (38%) were taken only in nest boxes and 2 squirrels (3%) were captured only in traps. The nest boxes were used moderately during June, with use decreasing in July and falling to zero by August. Use of the boxes was resumed in September and increased dramatically in October, reaching a maximum in November with sustained high use through February. Trap response followed a similar pattern; however, trapability fell to its lowest point in October and reached a maximum in January. Overall, 63 of the 100 nest boxes were used by flying squirrels. Forty-seven of the boxes were used as nesting sites, 15 as feeding stations, and 1 as a defecatorium. In late September, 6 litters which had been born elsewhere in late August to early September, were moved into nest boxes. The mean litter size was 3.3. One newly born litter of 2 was found in mid-February. Males were in reproductive condition from June through July and from November through January.

PRELIMINARY STUDIES OF VITELLOGENESIS IN THE BLUE CRAB, *CALLINECTES SAPIDUS*. Chi-Ying Lee and R. Douglas Watson, The University of Alabama at Birmingham.

In preliminary studies of vitellogenesis in the blue crab, *Callinectes sapidus*, tissue extracts were separated by non-dissociating polyacrylamide gel electrophoresis (PAGE). A distinct protein band was present in hemolymph, but not ovary or hepatopancreas, from an early vitellogenic adult female. This protein band was characterized by low electrophoretic mobility, and contained a lipid moiety as demonstrated by positive staining with Sudan Black. Furthermore, the protein was absent in mature males and immature females, indicating it is female-specific and associated with ovarian maturation. A protein with the above characteristics was also detected in fully developed ovary, but not hemolymph or hepatopancreas, from an adult female. When electroeluted and separated by SDS-PAGE, this ovarian protein was found to contain 2 major (110 and 86 kD) and 3 minor (219, 188 and 168 kD) polypeptide subunits. The results suggest that the hemolymph protein and its ovarian counterpart are vitellogenin (Vg) and vitellin (Vn), respectively. Furthermore, the presence of Vg in hemolymph prior to detection of Vn in ovary, is consistent with the hypothesis that Vg, being the precursor of Vn, is synthesized extraovarially, transported in hemolymph, and taken up by maturing ovary.



## Abstracts

PRIMARY STRUCTURE OF  $\beta$  SPECTRIN ( $\beta$  FODRIN): RELATIONSHIP TO GLOBIN SEQUENCES. Yupo Ma, Warren E. Zimmer, Beat M. Riederer and Steven R. Goodman, Department of Structural and Cellular Biology, College of Medicine, University of South Alabama, Mobile, AL 36688.

Brain spectrin (fodrin), a major ubiquitous cytoskeletal protein participates in cell morphogenesis, neurotransmitter release and regulation of the lateral mobility of N-CAM 180. It consists of  $\alpha$  and  $\beta$  subunits that form antiparallel 100 nm long fibrous heterodimers, and the heterodimers associate head-to-head to form 200 nm tetramers. The  $\beta$  subunit of spectrin is functionally important because it interacts with other molecules including F-actin, ankyrin and synapsin I. Elucidating the details of the primary structure of  $\beta$  spectrin will facilitate understanding its functional interactions and may predict new functions for this molecule. We have determined the first full length sequence of nonerythroid  $\beta$  spectrin ( $\beta$  SpIIa). The nucleotide sequence contains 7165 basepairs encoding 2363 amino acid residues, which comprise 17 typical repeat units which share 59% identity with  $\beta$  SpIa ( $\beta$  subunit of human rbc spectrin). The predicted molecular weight of  $\beta$  brain spectrin from the derived amino acid sequence is 274,449 daltons. Combining the knowledge of previously reported functional studies with our  $\beta$  SpIIa primary structure, it is possible to make a number of predictions regarding functional sites within this  $\beta$  spectrin molecule. Interestingly, the analysis of the  $\beta$  SpIIa sequence indicated striking homology and similar structural characteristics of brain  $\beta$  spectrin repeat B11 and B12 to the heme-binding domain of globins. We have demonstrated that purified brain  $\beta$  spectrin binds

DIVERSITY OF FISHES AND THEIR RIVERINE HABITATS IN THE CAHABA RIVER SYSTEM. J. Malcolm Pierson, Alabama Power Company, P. O. Box 2641, Birmingham, Alabama 35291.

The Cahaba River, a major tributary of the Alabama River in the Mobile Basin, is the longest remaining free-flowing stream in the State. The headwaters of the Cahaba are located in St. Clair County northeast of Birmingham within the Valley and Ridge physiographic region. The Cahaba flows in a southwestern and then southern direction through the Fall Line Hills and Black Belt districts for 191 river miles before joining the Alabama River in Dallas County southwest of Selma. The Fall Line cuts diagonally across the drainage from near Greenpond in Bibb County to a point south of Montevallo in Chilton County. The variety of geologic formations that are crossed by the Cahaba contributes to a diversity of riverine habitats in both the main channel and its tributaries. This rich habitat diversity has resulted in the development of a large number of fish species many of which are endemic to the Mobile Basin. One hundred and thirty-one species of fishes have been recorded from the Cahaba. The Cahaba River drainage is now recognized by ichthyologists and other biologists as one of the most diverse systems for its size in North America in terms of species richness of fishes as well as aquatic invertebrates.

## Abstracts

REACTIVITY OF INSECT YOLK POLYPEPTIDES WITH ANTI-UBIQUITIN  
Susila Dorai-Raj and Jim Bradley, Dept. of Zoology and Wildlife,  
Auburn University, AL 36849. Antonella Cecchetti, Dept. of  
Biomedicine, University of Pisa, Italy.

Ubiquitin is a low molecular weight polypeptide (8600 kD) which is involved in the energy dependent proteolysis of intracellular proteins. In the insect species studied, the vitellins undergo programmed degradation during oogenesis and embryogenesis. Antiserum to ubiquitin (Sigma) was found through Western blotting, to bind specifically to the 49 kD yolk protein (YP) IV and embryonic protein 6 of Acheta domesticus, the house cricket. In Western blots using ubiquitin antiserum against follicle and egg samples from the walking stick, Carausius morosus, the antibody was specific for a 50 kD polypeptide A3' present in the chorionated egg which is the processed form of yolk protein A3 in these insects. Egg and hemolymph protein of Ceuthophilus spp., the camel cricket, were unreactive with commercial anti-ubiquitin serum. The functional significance of the reactivity of ubiquitin antiserum with specific yolk polypeptides programmed for later degradation during embryogenesis is yet to be examined. A rabbit polyclonal antibody against ubiquitin has been developed and is reactive with A3' in Carausius.

Supported by the Alabama NSF-EPSCOR Program in Molecular, Cellular and Developmental Biology (Grant #RII-8610669) and HATCH Project 665 (AAES).

Na:Ca EXCHANGE IN CULTURED MESANGIAL CELLS FROM DAHL/JOHN RAPP SALT-SENSITIVE, DAHL/JOHN RAPP SALT-RESISTANT, AND SPRAGUE DAWLEY RATS.  
Amy Alderman and Jeannette Runquist, Birmingham-Southern College, Birmingham, AL 35254. P. Darwin Bell, 827 Sparks Center, UAB Station, Birmingham, AL 35294.

Mesangial cells from Sprague-Dawley rats (SD), Dahl/John Rapp salt-sensitive (SS/Jr), and salt-resistant (SR/Jr) rats were tested for the presence of a Na:Ca exchange mechanism. This exchange mechanism can be activated in the reverse direction by removal of extracellular Na, a maneuver which results in an increase in intracellular [Ca]. The experiments were designed to determine if 1) a Na:Ca exchange mechanism is present and 2) if the level of activity differs in these groups. Mesangial cells were cultured from 5-6 week old SD, SR/Jr, and prehypertensive SS/Jr rats maintained on 1% NaCl diet. Cells were subpassaged onto glass coverslips and studied when 50-80% confluent. Cells were loaded with the fluorescent dye Fura-2, and intracellular [Ca] was determined using a microscope based photometer system. In cells from SD rats, resting intracellular [Ca] was 69nM and removal of Na from the extracellular bath increased cytosolic [Ca] by 248nM. In contrast removal of extracellular NaCl resulted in an increase in cytosolic [Ca] of 283nM in cells from SR rats and 416nM in cells from SS rats. Time required for onset of response was 129 sec. in SD compared to about 70 sec. in both SS and SR rats. Readdition of external NaCl activated a forward mode exchanger which in most cells resulted in a decrease in intracellular [Ca]. In SD the magnitude of that decrease was 43nM compared to 13nM in SS cells. SR cells exhibited much variation in response and mean [Ca] change was 13nM. These preliminary data indicate that the Na:Ca exchanger is more active in cells derived from SS/Jr and SR/Jr than from SD rats.

## Abstracts

COMPARISON OF THE CATALYTIC AND INHIBITORY PROPERTIES OF *Pachysolen tannophilus* XYLOSE REDUCTASE TO RAT LENS ALDOSE REDUCTASE. R. Alan Davis and Jack DeRuiter, Division of Medicinal Chemistry, Department of Pharmacal Sciences, School of Pharmacy, Auburn Univ., Auburn, AL 36849-5503.

The catalytic and inhibitory profiles of xylose reductase isolated from the yeast *Pachysolen tannophilus* (PTXR) are compared to those of aldose reductase (AR) isolated from rat lens. While both PTXR and rat lens AR are NADPH-specific enzymes and have an affinity for a variety of substrates such as D-xylose (D-xyl), D,L-glyceraldehyde (D,L-gly), and 4-nitrobenzaldehyde, the enzymes differ in their substrate affinity profiles. The degree of cofactor specificity by these two enzymes (NADPH vs NADH) is comparable in that both have a greater affinity for NADPH than for NADH as evidenced by their relative  $K_m$  values.

PTXR is not inhibited by standard inhibitors of AR. Representative members of various AR inhibitors were screened against PTXR, e.g. tolrestat, benzopyran and benzoxindole acetic acids, several arylsulfonylamino acids, a quinoline, and sorbinil. Only one of the compounds tested (1-naphthosulfonylsarcosine) displayed appreciable inhibition of PTXR with either D,L-gly or D-xyl as the substrate (39% and 25%, respectively). Thus, the data indicates that PTXR may not possess the inhibitor binding site found in rat lens AR.

THE EFFECTS OF FOOD QUALITY AND TEMPERATURE ON JUVENILE GROWTH AND REPRODUCTION IN THE FRESHWATER GASTROPOD *PHYSELLA CUBENSIS* (BASOMATOPHORA: PHYSIDAE). Donald L. Thomas and James B. McClintock, University of Alabama at Birmingham. Birmingham, AL 35294.

Growth rates, mortality and reproductive output of *Physella cubensis* varied with both quality of diet and temperature. Similar-aged juvenile snails (0.5-0.8 mm shell length) raised on a low quality diet grew slower than snails raised on medium and high quality diets at similar experimental temperatures (15, 25 and 35°C). Growth rates of snails fed medium and high quality diets were similar within the three temperature treatments. Snails raised at 25°C grew faster than those raised at 15° and 35°C and experienced 100% mortality after 140 days. Snails raised at 35°C grew slowly and experienced 100% mortality after 85 days. Snails raised at 15°C had growth rates similar to those in the 35°C treatment until day 116, after which growth rates increased. Snails raised at 15°C experienced minimal mortality during the course of the experiment (52% at termination of experiment on day 151). Oviposition did not occur in snails raised in low quality food treatments or in snails raised at 35°C. First oviposition for medium and high quality food treatments occurred at 18 and 53 days for 25 and 15°C treatments, respectively. Total reproductive output was similar for snails raised in medium and high quality treatments in both 15°C and 25°C treatments. These data indicate that food quality and temperature may place significant constraints on growth, mortality and reproductive condition of *P. cubensis*. These factors, as well as precipitation, habitat structure and predation are hypothesized to be important in regulating the population dynamics of *P. cubensis* in the field.



## Abstracts

IMMUNOCYTOCHEMICAL DETECTION OF FOLLICLE-STIMULATING HORMONE (FSH) OR FSH-LIKE IMMUNOREACTIVITY IN EPIDIDYMIS OF MATURE MOUSE. William B. Brumlow and Caroline Adams, Biology Department, Auburn University at Montgomery, Montgomery, AL 36117.

Follicle-stimulating hormone (FSH) binds to the Sertoli cells of the testis of mice, rats, and pigs where it stimulates DNA, mRNA, protein and phospholipid synthesis. FSH also increases the number of and steroidogenic activity of Leydig cells in the rat testis. In the hamster and rat ovary, FSH increases the accumulation of DNA polymerase  $\alpha$ , increases DNA synthesis, and induces mRNA synthesis. In the present study, a standard immunoperoxidase technique (PAP) was used to detect the binding of endogenous FSH or FSH-like peptides to the epididymis of the mature mouse. Throughout the epididymal duct, a positive reaction for peroxidase, indicating FSH or FSH-like peptide binding, occurred in the nuclei of the principal cells. The most intense positive reactions were in segments 2 and 3 (middle and distal caput epididymidis). The least intense positive reaction was located in the nuclei of segment 5 (cauda epididymidis). The significance of such binding to the epididymis is uncertain but FSH may stimulate DNA and/or mRNA synthesis in the principal cells.

Life cycle Variation of Elimia acutocarinata; Environmental or Genetic? Brent Bailey, and Frank Romano, Dept. of Biology, Jacksonville State University, Jacksonville, AL 36265

Variations in freshwater organisms life history traits have been attributed to both environmental and/or genetic causes. This study entails a reciprocal transfer between two neighboring populations of the freshwater snail Elimia acutocartnata at Cave Spring Georgia to determine if such variations in life histories are environmentally or genetically induced. One population, located in Cedar Creek (CC), lives in a natural watershed creek, while the other, Cave Spring (CS), lives in the outflow of a freshwater spring. A major difference between the two environments is that CS is much more thermally stable ( $\pm 3.9$  degrees C) and does not show the more typical seasonal variations as does CC ( $\pm 7.1$  degrees C). Snails located in CC (CC natives = 0.007 mm/day; and CC transfers=0.055 mm/day) showed a higher growth rate than the snails located in CS (CS natives=0.007 mm/day; and CC transfers=0.003 mm/day). The snails located in CC were more fecund (CC natives=8.7 eggs/adult; CS transfers=13.9 eggs/adult) than snails located in CS (CS natives=3.8 eggs/adult; CC transfers=3.5 eggs/adult). The most significant life history difference was that the CS population was bivoltine, reproducing in the fall only. CS adults transferred to CC retained a second reproductive phase while CC adults transferred to CS did not attempt a second reproduction.

## Abstracts

### CHEMISTRY

RADIOACTIVE ELEMENTS: K-40, H-3 & U-238 SERIES. REACTION RATES, CONCENTRATION AND COMPARATIVE TOXICITY TO MAN. Carlton D. Whitt, Ret. Civil Service, TVA & Monsanto, 601 Schilling, Athens, AL 35611

As U-238,  $t_{1/2} = 4.51$  billion yr. goes to Pb-206 by 8 alpha, 6 beta reactions, all 14 daughters, except Rn-222, are very poisonous but not really radioactive hazards to man. K-40 and H-3 are not toxic to man but are greater nuclear threats, especially H-3 (tritium). The activities of parent U-238 and all its daughters are constant,  $K_1N_1 = K_2N_2 = \dots = K_nN_n$ . Thus at equilibrium U-238 and all its daughters are formed at the  $t_{1/2}$  rate and all active daughters formed react at their own  $t_{1/2}$  rates. Maximum amounts of each daughter present in U-238 can be calculated. A Curie ( $3.7 \times 10^{10}$  counts per sec.) of Ra-226 is 1.0 gram, U-238 is 3.3 ton, Rn-222 is 6.5 millionth gram. 1.0 gram atomic weight of any element has  $6.02 \times 10^{23}$  atoms. The radon content in a column of air 13.1 ft. high over a square mile area containing 4,000 pCi radon per liter of air is 0.03 ml. radon gas at NTP, a volume less than the size of one drop of water. Maximum amount of radon per gram of U-238 is  $2.16 \times 10^{-12}$  grams. One liter of air with 4.0 pCi radon and 0.005% CO by volume has 0.148 cps radon and has  $1.9 \times 10^{13}$  molecules CO gas per atom of radon. 3.0 grams of H-3 with  $t_{1/2}$  of 12.26 yr. will give as many cps as 96,370 tons U-238 or 6,883 tons of U-238 including its 14 active daughters. The  $t_{1/2}$ 's make a big difference. As Ra-226 goes to Rn-222, alpha particles can escape from minerals but large radon atoms can't. To be dangerous to man, alpha particles must be given off inside our bodies; beta rays (high energy radiation) can pass through our bodies damaging tissues, e.g. Co-60, H-3 and Cs-137. Real nuclear dangers come from what man and his nuclear technology have done; not natural radioactivity.

### STUDIES ON THE CYTOTOXICITY OF DDT ON VASCULAR SMOOTH MUSCLE CELLS

Eric Taylor and Ephraim T. Gwebu, Chemistry Department, Oakwood College, Oakwood Road, Huntsville, AL 35896

The health effects are a concern to the people of North Alabama because of a history of contamination. The purpose of this study is to study the cytotoxicity of DDT on vascular smooth muscle cells. The primary culture of guinea pig thoracic aorta was established using the method of Huttner et al *Tissue Culture Association (TCA) MANUAL 3*: 633, 1977. The cells are grown to confluency using a 10% fetal bovine serum growth medium. The confluent cells are split using Trypsin approximately seven days following the establishment of the primary culture. Cell populations are determined using the hemocytometer. Approximately 10,000 cells are placed in flasks and allowed to seed for 2-4 days. The seeded cells are exposed to various concentrations of DDT. Cell viability is done using the trypan-blue exclusion method (Chamley-Campbell et al . *Physiol. Rev.* **39**: 1-6, 1979. The results will be discussed.

Supported by Grant # T34-GM08259



## Abstracts

SYNTHESIS, CHARACTERIZATION, AND BIOLOGICAL EVALUATION OF SOME DEUTERATED INDOLEALKYLAMINES. Joyce Chiao and Philip E. Morris, Jr. Dept. of Chem., Univ. of Ala at Bham, Bham, Al 35294. John M. Beaton, Dept. of Neuropsychobiology, Univ. Of Ala at Bham, Bham, Al., 35294.

It is well known that substitution of a deuterium for a hydrogen atom produces a stronger bond and that the rate of reaction at the center bearing the deuterium will be diminished relative to the hydrogen containing compound. This effect is known as the kinetic isotope effect. Of interest in our laboratory is the metabolism of the endogenous hallucinogenic indolealkylamines *N,N*-dimethyltryptamine (DMT) and 5-methoxy-*N,N*-dimethyltryptamine (5-MeODMT). Drug loading studies have demonstrated an *in vivo* kinetic isotope effect for both the metabolism and behavior disrupting effect of  $\alpha,\alpha,\beta,\beta$ -tetradeutero-DMT ( $D_4$ DMT) vs DMT. However, it is not known which deuterium position in the side chain is responsible for the observed effect. Thus we have proposed the synthesis of several deuterium labelled analogs that can be used as probes in studying the role of the side chain hydrogens in the metabolism of the compounds. It should be possible to correlate the side chain position important for metabolism by comparing the rate of clearance for the two deuterated DMT isomers with  $D_4$ DMT and comparing the behavior disrupting effects to that of  $D_4$ DMT. An *in vitro* assay will be used to study 5-MeODMT and the deuterated analogs which uses purified monoamine oxidase. Employing established synthetic techniques we have synthesized some regioselectively deuterated analogs of DMT and 5-MeODMT and their synthesis and importance will be discussed. The deuterium labels were confirmed by  $^1H$ ,  $^2H$ ,  $^{13}C$  NMR spectroscopy and mass spectrometry.

AMBIENT CONCENTRATIONS OF TROPOSPHERIC CARBONYLS AT A RURAL SITE IN TENNESSEE. Valarie G. Henry, V. Kirk James, Gary A. Winchester, and Thomas P. Murray, Department of Chemistry and Industrial Hygiene, University of North Alabama, Florence, AL 35630. Elizabeth M. Bailey, Atmospheric Science Department, Tennessee Valley Authority, Muscle Shoals, AL 35660.

Ambient tropospheric concentrations of formaldehyde, acetaldehyde, acetone, and propionaldehyde were measured at a rural field site operated by The Tennessee Valley Authority in Giles County Tennessee. Sampling was integrated over two hour periods by passing air samples through cartridges coated with 2,4-dinitrophenylhydrazine (2,4-DNPH). Tropospheric carbonyl concentrations were determined by eluting the 2,4-DNPH-carbonyl derivatives from the cartridges and determining the concentration of the derivatives using high performance liquid chromatography. The data were collected during July and August of 1991.

Additional meteorological data, as well as trace gas concentrations from the same site, have been correlated to the carbonyl data in an attempt to examine the role of biogenic hydrocarbons in regional ozone formation. The study is part of the Southeastern Regional Oxidant Network (SERON) which has sponsored field studies in several southern states.



## Abstracts

INDOLEALKYLAMINES: AN OVERVIEW. Philip E. Morris, Jr., Department of Chemistry, Univ. of Ala at Bham, Bham, AL, 35294. John M. Beaton, Department of Psychiatry, Univ. of Ala at Bham, Bham, AL, 35294.

Indolealkylamine compounds consist of an indole ring with an ethylamine side chain at the 3-position. As well, there may be additional substitution on the aromatic ring. Among the many naturally occurring indolealkylamines found in nature are a number of pharmacologically interesting compounds. Among these are the potent hallucinogens lysergic acid diethylamide (LSD), psilocybin, bufotenine, *N,N*-dimethyltryptamine (DMT) and 5-methoxy-*N,N*-dimethyltryptamine (5-MeODMT or OMB), the tetrahydro- $\beta$ -carbolines (THBCs), and serotonin, a neurotransmitter. The discovery that many mammalian systems possess the ability to form DMT, 5-MeODMT and the THBCs *in vivo* as well as metabolize these compounds presents several interesting lines of study regarding their function. Results from studies initiated in our laboratory with DMT, 5-MeODMT and the THBCs will be presented. A description of the gas chromatographic mass spectrometric (GC\MS) assay we have devised to identify and quantitate these compounds isolated from various biological matrices will be discussed. Crucial to these studies is the use of deuterated analogs which we have synthesized. Results will also be presented that describe the biogenic pathway for these compounds from tryptophan as well as the *in vivo* metabolic fate following intraperitoneal injection in rats. Differences in the metabolism and behavior disrupting ability of DMT versus  $\alpha,\alpha,\beta,\beta$ -tetradeutero-DMT will also be discussed.

AMBIENT CONCENTRATIONS OF TROPOSPHERIC CARBONYLS AT A RURAL SITE IN TENNESSEE. Valarie G. Henry, V. Kirk James, Gary A. Winchester, and Thomas P. Murray, Department of Chemistry and Industrial Hygiene, University of North Alabama, Florence, AL 35630. Elizabeth M. Bailey, Atmospheric Science Department, Tennessee Valley Authority, Muscle Shoals, AL 35660.

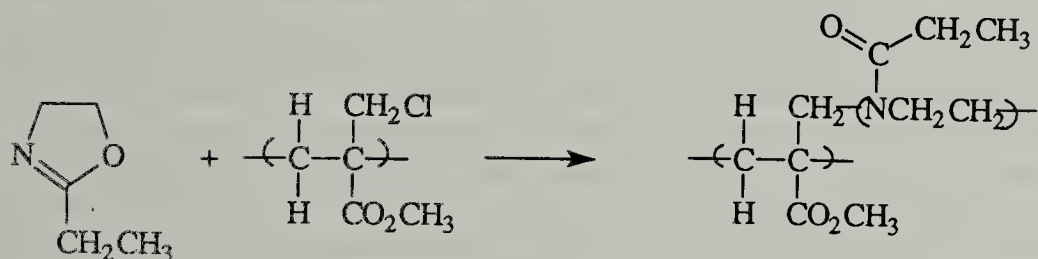
Ambient tropospheric concentrations of formaldehyde, acetaldehyde, acetone, and propionaldehyde were measured at a rural field site operated by The Tennessee Valley Authority in Giles County Tennessee. Sampling was integrated over two hour periods by passing air samples through cartridges coated with 2,4-dinitrophenylhydrazine (2,4-DNPH). Tropospheric carbonyl concentrations were determined by eluting the 2,4-DNPH-carbonyl derivatives from the cartridges and determining the concentration of the derivatives using high performance liquid chromatography. The data were collected during July and August of 1991.

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## Abstracts

REACTION OF 2-ETHYL-2-OXAZOLINE WITH POLYMERIZED METHYL  $\alpha$ -CHLOROMETHYLACRYLATE. Calvin P. Monroe and Adriane G. Ludwick, Chemistry Department, Tuskegee University, Tuskegee, AL 36088.

The purpose of the title reaction is to attach ethyloxazoline repeat units to the chloromethyl pendants of poly(methyl  $\alpha$ -chloromethylacrylate). This synthesis is one of a number of steps planned towards the final objective of synthesizing a therapeutic polymer. In order to accomplish this synthesis, 0.8 g of poly(methyl  $\alpha$ -chloromethylacrylate) was placed in a test tube along with 5 ml of 2-ethyl-2-oxazoline. The test tube was purged with nitrogen for approximately 10 minutes and then reacted at 128°C for a period of 48 hours. The final product appeared as fine light brown crystals. As a control, 2-ethyl-2-oxazoline was heated under the same conditions used for the reaction of the chloro polymer with the oxazoline. The 2-ethyl-2-oxazoline did not polymerize in the absence of poly(methyl  $\alpha$ -chloromethylacrylate). This indicates that the polymerization of 2-ethyl-2-oxazoline was initiated by the  $\alpha$ -chloromethyl group of the polymer. Spectral data (infrared and nuclear magnetic resonance) further indicates that the reaction shown in the following equation has occurred. Additional



analytical information (gel permeation chromatography and elemental analyses) will be obtained in order to confirm more completely the structure of the copolymer. Partial hydrolysis of the copolymer is planned in order to give a water-soluble compound which can be further grafted. Pendants of biological importance will be utilized in this grafting. (Supported by NIH RR08091)

EXTRACTION OF POLYMERS FROM CLAY BY SCFE. Terrence Tipton, Civil Engineering Laboratory, Tyndall AFB, Florida 32403-6001. Larry Gerdorn, Division of Natural Science, Mobile College, Mobile, AL 36663.

Aromatic molecules are known to undergo polymerization reactions when heated in the presence of a metal cation supported on montmorillonite clay. In the present study toluene was heated with clay containing copper(II) ions. The purpose of this study was to determine if supercritical fluid extraction would efficiently remove the reaction products from the clay for identification by GC/MS. Progress to date will be reported.

Dr. Gerdorn was supported as a Research Associate by the Air Force Office of Scientific Research Summer Faculty Research Program for 1991.

## Abstracts

TITANIUM-CONTAINING PRECERAMIC POLYMERS: SYNTHESIS, CHARACTERIZATION AND PROCESSING CONDITIONS FOR COMPOSITES. Hanmantrao P. Phadtare, Adriane G. Ludwick and Taleb H. Ibrahim, Chemistry Department, Materials Research Laboratory, Tuskegee University, Tuskegee, AL 36088.

Polytitanocarbosilane (PTC) is useful as the precursor polymer for ceramic matrices and fibers. PTC was synthesized from boron-containing polycarbosilane and titanium tetrabutoxide. The conditions to synthesize PTC reproducibly were examined. The reaction is exothermic during pyrolysis at 220°C. Hence maintaining that temperature was important if the preparations were to be similar. PTC was characterized by IR, NMR (<sup>1</sup>H and <sup>13</sup>C), GPC and elemental analysis. IR and <sup>1</sup>H NMR were used to determine the extent of reaction. Specifically, in the IR spectra, the Si-H absorption at 2100 cm<sup>-1</sup> decreases relative to the Si-CH<sub>3</sub> absorption at 1255 cm<sup>-1</sup> as the reaction progresses. Evidence for the incorporation of titanium into the polymer was found in IR, <sup>13</sup>C NMR and GPC. Processing conditions for the formation of composites (SiC/TiC as matrix and SiC whiskers as reinforcement ) were examined. Scanning electron micrographs of composite blocks cold pressed at 10,000 psi and pyrolyzed at 1500°C showed improved consolidation of matrix and reinforcement compared to blocks pyrolyzed at 1000°C. Considerably less voids were observed in the blocks pyrolyzed at 1500°C compared to ones pyrolyzed at 1000°C. Composite blocks with one percent aluminium pyrolyzed at 1000°C were also examined. Further work will include examination of blocks pyrolyzed at temperatures greater than 1500°C. Changes will be made in some of the parameters such as matrix to reinforcement ratio, rate of heating, and addition of sintering aids. [The support of the Office of Naval Research, Grant No. N00014-91-J-4035, is gratefully acknowledged.]

DRUGS OF ABUSE: AN OVERVIEW. J. DeRuiter, F. T. Noggle, C. R. Clark and T. N. Riley, Department of Pharmacal Sciences, Auburn University and Department of Forensic Sciences, Auburn, AL 36849.

The abuse of a variety of drugs remains a significant problem worldwide. The drugs abused most commonly produce their effects via interaction with dopaminergic, noradrenergic, serotonergic, cholinergic and gabaminergic neurotransmitter systems of the central nervous system (CNS). The CNS-active drugs of abuse include hallucinogens (LSD, tryptamines, marijuana, phencyclidine), sedatives and depressants (barbiturates, benzodiazepines), stimulants (cocaine, amphetamine, methamphetamine), entactogens (MDMA or "Ecstasy"), analgesics/euphorants (opiates including morphine and heroin). However, some drugs are used for their peripheral actions. For example, the anabolic steroids (testosterone derivatives) are misused by athletes and body builders to stimulate muscle development. The sources and dosage forms of the more commonly abused drugs will be reviewed as well as their routes of administration, pharmacological effects, and the adverse reactions associated with their use.



## Abstracts

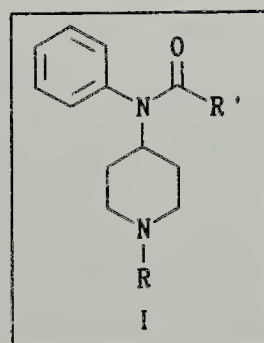
### POLY(ALKYLENE PHOSPHATE)S: SYNTHESSES AND APPLICATIONS.

Prakash Bharara and James B. Beal, Dept. of Chemistry, Univ. Montevallo, Montevallo, AL 35115. Gary M. Gray, Jimmy W. Mays and Keith E. Branham, Dept. of Chemistry, Univ. Ala. Birmingham, Birmingham, AL 35294.

Poly(alkylene phosphate)s are of interest because both the polymer backbone and phosphorus substituents can be readily varied. This suggests that it should be possible to prepare these polymers with specific properties for a variety of different applications. One problem encountered with these polymers is the preparation of polymers with relatively high molecular weights ( $\bar{M}_w \geq 10^4$  daltons). We have studied the polycondensations of dimethyl phosphite and several different diols using multinuclear ( $^{31}\text{P}$  and  $^{13}\text{C}$ ) magnetic resonance spectroscopy and size exclusion chromatography. We have found that these reactions can be used to prepare polymers with  $\bar{M}_w \geq 10^4$  daltons if the reaction temperatures are kept relatively low (below  $120^\circ\text{C}$ ) and if the phosphonic acid that is formed by a side reaction during the early stages of the polycondensation is removed by treatment with diazomethane. We have also observed that the polycondensation reaction does not occur with other phosphonates, and that the rate of the polycondensation reaction is quite sensitive to the nature of the diol. The results provide insights into the nature of the polycondensation reaction, and these will be discussed. This research was supported by grants from NSF-EPSCoR and the Graduate School of the University of Alabama at Birmingham.

**MEDICINAL CHEMISTRY OF THE 4-ANILIDOPIPERIDINE ANALGETICS.** Thomas N. Riley, J. DeRuiter and S. V. Andurkar, Department of Pharmacal Sciences, Auburn University, Auburn University, AL 36849-5503.

The first literature report for the 4-anilidopiperidine (4-AP) structural class (I) was published in 1959. These compounds were synthesized as cyclic analogues of the straight-chain basic anilide and diarylpropylamine (methadone) analgetics. Commercial development of I led to the marketing of fentanyl (I,  $\text{R} = \text{CH}_2\text{CH}_2-\text{C}_6\text{H}_5$ ) (1962), a significantly more potent analgetic than morphine with a faster onset and shorter duration of action. The relatively ease of synthesis of highly potent 4-APs coupled with the fact that both the pharmacologic profile and biodisposition characteristics of this class of analgetics are amenable to modification via appropriate structural design techniques has led to the development of a number of therapeutically useful agents.

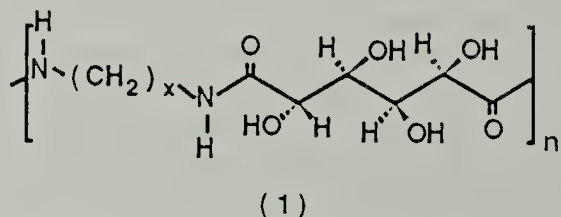


Our research group has been involved in the design, synthesis and pharmacological evaluation of various 4-AP analogues since 1970. The primary goal of our research has been to elucidate essential structural and stereochemical features of the 4-APs in the interactions with their target opiate receptor site.

## Abstracts

EQUILIBRIUM STUDIES OF D-GLUCARIC ACID ESTER/LACTONES IN ALCOHOL SOLUTIONS. Liang Chen and Donald E. Kiely, The University of Alabama at Birmingham, Birmingham, AL 35294

Poly(alkyleneglucaramides) (1) are the polymeric condensation products of D-glucaric acid and alkylenediamines. To prepare the polymers, a mixture of D-glucaric acid ester/lactones in alcohol is employed as the diacid monomer. The objectives of this study were: 1) to assign the structures of the ester/lactone monomers in alcohol solutions, 2) to determine how the equilibrium composition of these ester/lactones changed in the presence of acid or base or by extending heating. By employing spectroscopic method ( $^1\text{H}$  NMR,  $^{13}\text{C}$  NMR, and GC-MS) and by comparing them with authentically prepared samples, the three components of this mixture were identified as dialkyl D-glucarate, alkyl D-glucarate 1,4-lactone, and alkyl D-glucarate 6,3-lactone. Heating the ester/lactone mixture under vacuum produced a fourth species; D-glucaro 1,4;6,3-dilactone. This four component equilibrium mixture was converted to mostly dilactone in acetic acid or back to its original three component mixture in Methanol/HCl.



Straight Line Least Squares Analysis with Errors in both  $x$  and  $y$ . Michael B. Moeller, Department of Chemistry and Industrial Hygiene, University of North Alabama, Florence, AL 35632.

Ordinary least squares analysis (OLS) assumes that observed data points differ from true values only because of errors in measurement of the dependent variable. If there are significant errors in the  $x$  as well as the  $y$  observations, then the accepted practice is to employ formulae derived from a weighted least squares treatment. The literature on the subject claims that applying OLS for straight line regressions when there are errors in the  $x$  variable will produce biased estimators for the slope. Our investigation of this problem using Monte Carlo techniques has revealed that the analysis in the literature is incomplete. There is a previously unrecognized case for which OLS is the appropriate treatment even though the  $x$  observations have significant uncertainty. Furthermore, it is likely that this is the case which is applicable to many, probably most, situations in experimental chemistry.



## Abstracts

METAL-CONTAINING POLYMERS FOR LASER FUSION. Hariharasarma Maheswaran, Keith E. Branham, Gerald S. Vige, Shoyan Nan, Jimmy W. Mays and Gary M. Gray, Dept. Of Chemistry, Univ. Ala. at Birmingham, Birmingham, AL 35294.

The incorporation of early, 3d transition metals into the polymer shells used to hold the deuterium-tritium fuel in laser fusion experiments allows the temperature and pressure of the fusion process to be measured. The best way to incorporate the metal into the polymer shell is to attach the metal to the polymer so that it is uniformly distributed throughout the shell. These metal containing polymers ideally should have a narrow molecular weight distribution, have good solubility in methylene chloride and contain between 0.25 and 1.00 aton % of the metal. In order to meet these requirements, it is necessary to prevent the metal from coordinating to ligating groups on different polymer chains and thus crosslinking the polymers. We have studied several different methods for the preparation of these metal-containing polymers including synthesis of a ligating site on a preformed polymer, attaching a metal complex to a reactive site on a preformed polymer and polymerizing metal-containing monomers. Each of these methods has certain advantages and disadvantages and these will be discussed. We have used these methods to form polymers containing Ti, Fe and Ni. This work was performed under subcontract #B130544 under DOE Contract #W-7405-ENG-48 at Lawrence Livermore National Laboratory.

SYNTHESIS AND CHARACTERIZATION OF A BLOCK COPOLYMER OF POLY(ETHYLENE OXIDE-ACRYLIC ACID). Eva Graham, Wendi Barner-Greene and Adriane G. Ludwick, Chemistry Department, Tuskegee University, Tuskegee, AL 36088.

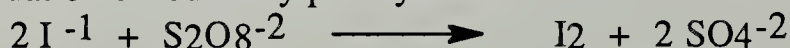
Polynucleotide analogs are molecules with polymeric, nonsugar phosphate backbones that are of interest as antiviral agents. The mechanism by which viral activity is inhibited is not completely understood. One suggestion is that growth of a virus is inhibited by interaction with the nucleic acid base pendant of the analog. A polynucleotide analog from poly(ethylene-oxide- acrylic acid) and 2-thyminelethanol is a possible anti-viral agent. A block copolymer with poly(ethylene oxide) (PEO) and methyl methacrylate (MMA) was synthesized according to a literature preparation (Y. Minoura and A. Nankano Macromolecular Synthesis, Vol 1, 1977). Analysis of the resulting copolymer indicated a small amount of the poly(methyl methacrylate) (PMMA) was incorporated into the copolymer. Solubility measurements of starting materials and copolymer were made in solvents of different polarities. The starting materials were soluble in toluene while the copolymer was not. The copolymer only swelled in toluene. The synthesis was altered to incorporate more PMMA into the copolymer. Chloroform was used to dissolve PEO before addition of MMA. Analysis showed more PMMA was incorporated into the copolymer using this approach. Characterization of this new copolymer is underway. A block copolymer of acrylic acid and ethylene oxide is being prepared. The acrylic acid copolymer, with increased acrylic acid grafting sites, will be reacted with 2-thyminelethanol to give a nucleic acid analog. [ Supported by NIH RR08091.]



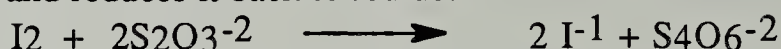
## Abstracts

**THE EFFECTS OF SOME TRANSITION METAL IONS ON THE OXIDATION OF IODIDE BY PEROXYDISULFATE ION.** Gregory W. Pippin, James L. Lambert, S.J., J. Jeff McAtee, Department of Chemistry, Spring Hill College, Mobile, Alabama, 36608.

The oxidation of iodide by peroxydisulfate ion is a slow reaction:



The time required for this reaction can be determined by adding thiosulfate ion as an "internal clock" with a small amount of starch indicator solution. Thiosulfate reacts rapidly with the iodine produced in the reaction, and reduces it back to iodide:



Therefore, no free iodine is present until all the thiosulfate is exhausted. When the thiosulfate is gone, the iodine formed reacts rapidly with the starch, forming a deep blue-black color.

The aim of this study was to examine the catalytic effects of some transition metal ions on the peroxydisulfate oxidation reaction. Since an internal clock is present, relative rates of reactions are determined by comparing uncatalyzed to catalyzed reactions.

**CLANDESTINE SYNTHESIS OF METHAMPHETAMINE DERIVATIVES.** J. DeRuiter, F. T. Noggle and C. R. Clark, Department of Pharmacal Sciences, Auburn University and Department of Forensic Sciences, Auburn, AL 36849.

The clandestine synthesis of methamphetamine and related amines continues to be the major source of these drugs of abuse. The most common methods employed for the synthesis of compounds of this type include: 1) reaction of phenyl-2-propanone with an amine under reducing conditions to produce racemic amines, and 2) reductive elimination of the benzylic hydroxyl group of chiral phenethanolamines such as the ephedrine or norephedrine to afford the amines as single enantiomers. Using liquid chromatographic (HPLC) and spectral techniques, a variety of illicit samples of methamphetamine and amphetamine were analyzed. In these analyses both the identity and stereochemistry of the specific amines and contaminants were determined; the stereochemistry was determined by chiral derivatization followed by reversed phase HPLC analysis using an achiral stationary phase. By identifying all components in the illicit drug sample and determining their stereochemistry it is possible to predict the synthetic route by which clandestine samples of methamphetamine and related amines are prepared.

## Abstracts

CONFORMATION OF  $\alpha$ -IONONE BY NOE AND MOLECULAR MECHANICS.  
Alexandre L. Smirnov and Donald D. Muccio, Department of Chemistry, University of Alabama at Birmingham, Birmingham, AL 35294.

The solution conformation of  $\alpha$ -Ionone was investigated by  $^1\text{H}$  NMR studies and molecular mechanics. After complete  $^1\text{H}$  NMR assignments and  $T_1$  measurements were made, the nuclear Overhauser effect (NOE) was measured between each pair of protons. These data were used to calculate interproton distances. For several proton pairs, the distances determined from NOE measurements were in good agreement with the distances calculated from molecular mechanics using Allinger's MM2(87) force field. For the conformational flexible butanone side chain of the molecule, the distances determined by NOE were between the distances calculated for different *s-trans* and *s-cis* conformers. By assuming that the butanone side chain was in rapid equilibrium between these two conformers, the conformationally averaged NOE distances were used to determine the probabilities of the *s-trans* and *s-cis* conformers. The *s-trans* conformer was determined to be more stable than the *s-cis* conformer, which is in agreement with the energies found from molecular mechanics.

## METABOLISM OF DDT BY VASCULAR SMOOTH MUSCLE CELLS

Paul Monk and Ephraim T. Gwebu. Chemistry Department, Oakwood College, Huntsville, Alabama 35896.

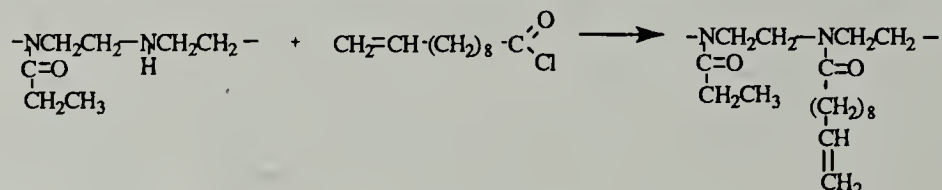
A problem of major concern is the health effects of DDT (Dichlorodiphenyl trichloroethane) among predominantly Black residents of the city of Triana in North Alabama. These residents have been drinking water and eating fish from a local river contaminated with DDT for nearly forty years. The Centers for Disease Control in Atlanta has shown serum DDT levels of these residents to be at least four times above acceptable levels. The purpose of the present study is to determine whether vascular smooth muscle cells metabolize DDT to DDE. The vascular smooth muscle cells were obtained from a primary tissue culture established in our laboratory. After the second passage the cell population was determined and appropriate dilutions were made for assays. The cells were exposed to a high and low concentration of DDT for a 24 hour incubational period. Extraction of DDT and its metabolites was done 3X using a 6:1 hexane/acetone solution. Analysis was performed using HPLC (Baseline Chromatography Data Acquisition System (Waters)).

Supported by NIGMS Grant# T34-GM08259

## Abstracts

GRAFTING OF UNDECENOYL CHLORIDE ONTO POLY(ETHYLENIMINE-co-ETHYLOXAZOLINE). Yusufu Dankaro and Adriane G. Ludwick, Chemistry Department, Tuskegee University, Tuskegee, AL 36088.

The broad physical and chemical properties of polyethyloxazoline has provided the stimulus for its use as a graft site. The purpose of the graft reaction shown below is to



synthesize a polymer that can be crosslinked to form a carrier matrix. The synthesis of the new copolymer involves the partial deacylation of polyethyloxazoline. The partially hydrolyzed copolymer is characterized by infrared and nuclear magnetic resonance spectroscopy. The graft copolymer is formed from the reaction of undecenoyl chloride with partially hydrolyzed polyethyloxazoline. The reaction is accomplished at room temperature using chloroform as the solvent. Spectral data (infrared and nuclear magnetic resonance) indicate that the reaction has occurred. Additional analytical information (gel permeation chromatography and elemental analysis) will be obtained for complete structural analysis. An attempt to crosslink the polymer using AIBN (azo-bis-isobutyronitrile) has been unsuccessful. Modification of the procedure for the attempted crosslink is underway. [The support of BP America is acknowledged.]

REACTIONS OF  $\text{As}(\text{NMe}_2)_3$  AND  $\text{Sb}(\text{NMe}_2)_3$  WITH ALUMINUM/MAGNESIUM ALKYLATING AGENTS. C. J. Thomas, L. K. Krannich, and C. L. Watkins, Department of Chemistry, University of Alabama at Birmingham, Birmingham, AL 35294

As a continuation of our NMR studies on the reactivity of aminoarsines with aluminum alkyls, we have been investigating the reactions of  $\text{As}(\text{NMe}_2)_3$  with  $\text{R}_3\text{Al}$  and  $\text{RMgX}$  and of  $\text{Sb}(\text{NMe}_2)_3$  with  $\text{R}_3\text{Al}$  as possible synthetic routes to tertiary arsines and stibines. The following tertiary arsines and stibines have been isolated in good yields from the aluminum alkyl reactions:  $\text{R}_3\text{M}$ , where  $\text{M} = \text{As}, \text{Sb}$ ;  $\text{R} = \text{Me}, \text{Et}, \text{Pr}^n, \text{Bu}^n, \text{Bu}^i$ . The other product from the reaction is the respective aminoalanes,  $[\text{R}_2\text{AlNMe}_2]_2$ . As might be expected, the reactions with the aminostibine are more facile than those with the aminoarsine. The results from the  $\text{RMgX}$  reactions with  $\text{As}(\text{NMe}_2)_3$  will be compared with those we previously obtained from the  $\text{RMgX/OCH}_2\text{CH}_2\text{OAsCl}$  reactions, which also yielded tertiary arsines. The utility and limitations of the various synthesis routes to tertiary arsines and stibines will be discussed. All the isolated compounds have been fully characterized, using IR, NMR, and MS.



## Abstracts

**PREDICTION OF  $^{19}\text{F}$ -NMR SIGNAL POSITIONS IN FLUOROARENETRI-CARBONYLCHROMIUM COMPLEXES.** J.R. Nanney, Department of Mathematics, Auburn University at Montgomery, Montgomery, AL 36117 and C.A.L. Mahaffy, Department of Chemistry, Auburn University at Montgomery, Montgomery, AL 36117, USA.

We have examined the  $^{19}\text{F}$ -nmr spectra of over forty mono- or difluoro-arenetricarbonylchromium complexes which also contain chloro, methyl, trifluoromethyl, methoxy, acetyl or amino substituents.

These spectra can all be predicted from the equation

$$\Delta^{\text{F}} = -13.820\mathfrak{F}_o + 32.411\mathfrak{R}_o - 12.569v_o + 1.087\text{MR}_o \\ - 1.326\mathfrak{F}_m + 1.766\mathfrak{F}_p + 12.963\mathfrak{R}_p - 135.645$$

where  $\mathfrak{F}_i$  is the field parameter of the substituent or the sum of the field parameters of the substituents if there are two in the  $i^{\text{th}}$  position,  $i$  = ortho, meta or para.  $\mathfrak{R}_i$ , the resonance parameter,  $v_i$ , the Charlton steric factor and  $\text{MR}_i$ , the molar refractivity are similarly defined. The above equation has a correlation coefficient of 0.99 when used to predict the  $^{19}\text{F}$ -nmr signal positions in this group of complexes. Of the twelve possible variables only seven are used in the above equation. The other five were found to be not statistically significant.

**SYNTHESIS, METABOLISM AND ANALYTICAL PROFILES OF 3,4-METHYLENEDIOXYAMPHETAMINES: DERIVATIVES OF "ECSTACY" (MDMA).** C. R. Clark, F. T. Noggle, A. K. Valaer and J. DeRuiter, Dept. of Pharmacal Sciences, School of Pharmacy, Auburn University, AL 36849.

The 3,4-methylenedioxyamphetamines (MDAs) have become common drugs of abuse in recent years. Various N-substituted and chain homologues of MDA are described as CNS stimulants having a unique empathy enhancing effect in humans and some of the these compounds may represent a new pharmacological class described as entactogens. The compounds can be synthesized from a number of available starting materials including 3,4-methylenedioxyphenylacetone, safrole and isosafrole. The N-methyl derivative of MDA, MDMA, is the most common drug of this class produced in clandestine laboratories. The analytical profiles of MDMA and MDA are very similar to other designer compounds in this series. The mass spectra of several of these isomers show the same molecular ion and major fragments as MDMA. The N-hydroxy derivative of MDA (NOHMDA) has appeared in street samples and studies in rats suggest its rapid metabolic conversion to MDA. The synthesis, analytical, pharmacological and metabolic properties of several MDA derivatives will be described.

## Abstracts

HEALTH RISK APPRAISAL OF BLACK SEVENTH-DAY-ADVENTISTS COMPARE TO GENERAL BLACK POPULATION. Ephraim T. Gwebu, Fred Murphy\*, Kibia Meyers, Sherman Cox. Chemistry Department, Oakwood College, Huntsville, Al. 35896, \*Centers for Disease Control.

The health status of an individual has a great deal to do with one's lifestyle. The lifestyles of black Seventh-Day-Adventists (SDA) were compared to that of the general black population and their associated risks to disease. In June, 1991, the Healthier People Questionnaire was administered to over 900 adult Black SDAs from Alabama, Mississippi, Tennessee and Kentucky attending the annual South Central Conference meeting in Huntsville, Alabama. The results were compared with general black population as reported in National Center for Health Statistics, PHS 1991:*Health United States, 1990*.

	Black SDAs	All BLACKS
Hypertension	22%	42%
High serum chol.	10%	25%
Diabetes	7%	18%
Smoking	0.3%	34%
Alcohol Abstinence	99%	35%

Recent studies suggest that these people live longer than the average black. (Murphy MG, et al. *Am. J. Pub. Health* 1990; 80: 984).

Supported by NIH Grant GM 08259

## MULTIPLY BONDED Al-N COMPOUNDS AND THEIR DIMERIZATION.

Tracy P. Hamilton, Dept. of Chemistry, Univ. of Alabama at Birmingham, Birmingham, AL 35294.

The synthesis of a compound with an Al-N double or triple bond is yet to be achieved. Attempts to make these compounds result in dimers or trimers. A theoretical investigation of the compounds  $\text{AlNH}_2$  and  $\text{AlNH}_4$  by *ab initio* quantum chemistry methods reveals that minima exist on the potential energy surface that are analogous to  $\text{C}_2\text{H}_2$  and  $\text{C}_2\text{H}_4$  (ethene). This is not a trivial result, as  $\text{Si}_2\text{H}_2$  and  $\text{Si}_2\text{H}_4$  are nonlinear and nonplanar, respectively. The dimerization of  $\text{AlNH}_4$  by the 2S-2S reaction path has an activation energy of zero. In contrast, the dimerization of ethene by the 2S-2S mechanism (symmetry forbidden) has a high reaction barrier. Likewise, the dimerization of  $\text{AlNH}_2$  is predicted to proceed with no energy barrier. Thus compounds with Al-N double and triple bonds will be difficult to synthesize and isolate; bulky or electropositive substituents may be used to respectively protect or stabilize the Al-N multiple bond.

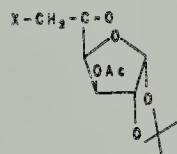
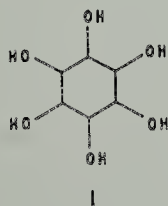
## Abstracts

**Nitronic Acids : Theoretical Studies.** Bharatam V. Prasad and Koop Lammertsma, Department of Chemistry University of Alabama at Birmingham, AL 35294.

Nitronic acids are compounds with  $=\text{NO}_2\text{H}$  functional group. They are as acidic as carboxylic acids. They are produced as intermediates in many reactions of aliphatic and aromatic nitro compounds, either by inter or intra molecular hydrogen abstraction. According to ab initio calculations at the G1 level of theory methane nitronic acid,  $\text{CH}_2=\text{NO}_2\text{H}$  is 14.14 kcal/mol less stable than nitromethane. The calculated ionization energy for nitromethane is 355 kcal/mol which is in excellent agreement with pulsed ICR experimental value 358 kcal/mol. Calculated acidity of methane nitronic acid is comparable to hydroxy acetic acid and nitrous acid.  $\text{CH}_2=\text{NO}_2\text{H}$  contains a cis O-N-O-H arrangement of the  $\text{NO}_2\text{H}$  group. A structure with a trans O-N-O-H arrangement corresponds to a transition structure. But such a trans arrangement can be stabilized by intramolecular hydrogen bonding as in the aci form of cis-2-vinyl alcohol and cis-2-nitrovinylamine. 1,5 shifts in cis-2-nitrovinylalcohol, cis-2-nitrovinylamine and cis-1-nitropropene show an energy barrier of 9.0, 16.7 and 45.5 kcal/mol respectively at MP4/6-31G\*\*//MP2/6-31G\* level indicating that intramolecular hydrogen bonds strongly facilitate the 1,5 shift. Bond properties and atomic charges of these compounds have been analyzed.

**PREPARATION OF 6-DEOXY-6-SUBSTITUTED-5-KETO DERIVATIVES OF D-GLUCOSE AS PRECURSORS FOR CHIRAL CYCLITOLS.** David W. Morton and Donald E. Kiely, Dept. of Chemistry, Univ. of Alabama at Birmingham, Birmingham, AL 35294.

Cyclitols, polyhydroxycyclohexanes, (I) are naturally occurring molecules that play a number of important biochemical roles such as serving as growth factors for organisms and as second messengers for cell recognition.<sup>1</sup> Because of the biological importance of this class of compounds a general chiral synthetic route to them would be an important development. Most all of the existing routes to modified cyclitols has been from the elaboration of common cyclitols and requiring resolution of the final product from a racemic mixture.<sup>2</sup> In contrast, our proposed route to the chiral cyclitols involves generating the product directly from acyclic carbohydrate precursors (Scheme). Key intermediates in our synthesis are 6-deoxy-6-substituted-5-keto-D-glucose derivatives (1 a-c). The synthesis and NMR characteristics of 1 a-c will be described.



- 1 a    X = Cl  
 b    X = Br  
 c    X = NH<sub>2</sub>



## Abstracts

Comparative Attitudinal Study of Seventh-day Adventist 6-12th graders with non-Seventh-day Adventist 6-12th graders toward Cigarette Smoking.

Chelsea Broaden and Ephraim T. Gwebu. Department of Chemistry, Oakwood College, Huntsville Alabama 35896.

Adolescents who are most vulnerable to developing smoking habits, are those who have a low self-esteem and who's parent(s) smoke. Other studies indicate that a disproportionate number of African-Americans smoke.

Seventh-day Adventists (SDAs) are a conservative Christian denomination with more than 6 million members worldwide and about 1 million in the United States. The majority follow a unique lifestyle. Church policy dictates that members abstain completely from tobacco and alcoholic beverages. The life expectancy of African-American SDAs is significantly higher than that of other African-Americans. Over 98% of African-American SDA College students do not smoke. The present study was designed to compare the attitudes of African-American Seventh-day Adventist students in grades 6 through 12th with non-Seventh-day Adventist (6-12th grade) students toward cigarette smoking.

There are dramatic differences in attitudes, psycho-social and smoking characteristics between African-American Seventh-day Adventist and non-Seventh-day Adventist 6-12th grade students. These differences and implications for health education will be discussed.

Supported by NIGMS Grant # T34 GM08259

SYNTHESIS OF ZIRCONIUM-CONTAINING POLYMER: POLYZIRCONOCARBOSILANE. Ralph P. Walker and Adriane G. Ludwick, Chemistry Department, Materials Research Laboratory, Tuskegee University, Tuskegee, AL 36088.

The purpose of generating a zirconium-containing polymer is to use it as a coating for silicon carbide (SiC) reinforcements (e.g., silicon carbide whiskers). The coating will be pyrolyzed to zirconium carbide (ZrC) and/or zirconium oxide (ZrO<sub>2</sub>). The coated SiC reinforcement will then be surrounded by a lithium aluminosilicate (LAS) matrix. This system can be considered an analog of a ceramic matrix composite (CMC) and can be used for study of the reinforcement/matrix interface of the composite. The interest in zirconium (a metal in the same family as titanium or hafnium) containing preceramic polymers has developed because of the possibility that ZrO<sub>2</sub> from the PZC can be formed on the SiC reinforcement and be used to induce crystallization of the LAS at the interface. ZrO<sub>2</sub> and titanium oxide (TiO<sub>2</sub>) both induce crystallization of LAS, but ZrO<sub>2</sub> is considerably less reactive with SiC than is TiO<sub>2</sub>. The different conditions explored for the synthesis of PZC will be discussed. The solubility of PZC was effected by a change in conditions. This as well as the general solubility of PZC for the best synthetic conditions will be discussed. Characterization of PZC by infrared, <sup>1</sup>H and <sup>13</sup>C nuclear magnetic resonance spectroscopy, and gel permeation chromatography gave insight into the structure of PZC. Preliminary experiments on the use of PZC to examine the interface of the SiC/LAS composite will be presented. [The support of the Office of Naval Research, Grant No. N00014-91-J-4035, is gratefully acknowledged.]

## Abstracts

Novel Optical Recording Processes in Materials Containing MnTPP Chromophores David E. Nikles, Terence J. Moran, and Phillip T. Burch  
Department of Chemistry and Center for Materials for Information Technology, University of Alabama, Tuscaloosa, Alabama 35487-0336.

Our interest in new laser recording process for optical data storage has led to this study of thin films containing porphyrin chromophores. The chromophores were five-coordinate complexes of manganese(III) tetraphenylporphyrin with either acetate, chloride, bromide, or p-toluenesulfonate axial ligands. These chromophores had an intense electronic absorption in the region of 465 to 485 nm and were therefore sensitive to the 488 nm line of the argon ion laser. The chromophores also had a weaker absorption in the region of 610 to 625 nm. Films consisting of MnTPP(X) in a polymeric binder were cast onto glass slides by spin coating. The films were subjected to 488 nm irradiation and any changes in optical properties were observed as changes in reflectance for a 632.8 nm helium-neon laser probe beam. For films containing either MnTPP(OAc) or MnTPP(Br), 488 nm irradiation with 50 to 1000 mW power gave reversible changes in the 632.8 nm reflectance. The changes occurred on a timescale of seconds. For films containing MnTPP(OAc), irradiation with 488 nm laser powers greater than 1000 mW gave permanent changes in the 632.8 nm reflectance and permanent yellow marks were formed in the green films.

ANABOLIC STEROIDS: ABUSE AND CLANDESTINE PRODUCTS. F. Taylor Noggle, Jr., Alabama Department of Forensic Sciences, P. O. Box 3510, Auburn, AL 36830.

The abuse and illicit trafficking of anabolic steroids is a major problem in the United States. Indications are that illicit trafficking of anabolic steroids is a \$300-400 million a year industry. The methods employed by steroid traffickers are traditional ones, i.e., diversion of legitimately manufactured steroids from United States sources, smuggling of steroids manufactured legally or illegally outside the United States, and formulation in clandestine laboratories. The production and distribution of counterfeit steroids not containing anabolic agents is also a problem. This presentation will examine the extent of steroid abuse in Alabama, orally active anabolic agents, oily solutions of anabolic steroids suitable for intramuscular administration, pharmacological properties, and adverse effects of anabolic steroids. Among the analytical techniques for identification of anabolic steroids employed by the Alabama Department of Forensic Sciences are reversed phase high performance liquid chromatography (HPLC) and gas chromatography/mass spectrometry (GC/MS). Illustrations of both legitimate and counterfeit anabolic steroids and the analytical techniques used to analyze confiscated samples will be described.

## Abstracts

COCAINE: METHODS OF ANALYSIS. F. Taylor Noggle, Jr., Alabama Department of Forensic Sciences, P. O. Box 3510, Auburn, AL 36830.

Cocaine is a naturally occurring alkaloid obtained from the leaves of the coca bush *Erythroxylum coca*, a shrub grown on the eastern slopes of the Andes Mountains. Cocaine is produced within eighteen months to three years and continues to be produced for the 40 year life span of the coca plant. The clandestine synthesis of cocaine from the coca leaf is a process which requires 4-5 days and differs significantly from the pharmaceutical manufacture of cocaine. The clandestine and pharmaceutical processes for obtaining cocaine are examined. While cocaine is the major alkaloid produced by the coca plant, several ecgonine-like alkaloids may be present in illicit samples. The primary technique used to identify the cocaine impurities is gas chromatography/mass spectrometry (GC/MS). "Crack" cocaine has rapidly become the most abused drug in Alabama. In addition, Federal law provides for more serious penalties for possession or sale of "crack" cocaine necessitating the differentiation of "crack" from cocaine salts. The techniques used to manufacture "crack" cocaine and the analytical techniques used to differentiate "crack" from cocaine salts are described.

BROWNIAN DYNAMICS SIMULATION. Jeffrey D. Madura, Department of Chemistry, University of South Alabama, Chem Bldg. Rm 223, Mobile, AL 36688.

A general purpose Brownian dynamics program has been developed. The program can calculate bimolecular diffusion-controlled rate constants, electrostatic free energy of binding, electrostatic fields, and the  $pK_a$  of titratable sites in proteins. This poster will present the methods used to perform such computations, describe the program's functionality and cite several applications utilizing the program.

CHROMATOGRAPHY OF CHROMIUM(III) NUCLEOTIDES. J. Rawlings, Chemistry Dept., Auburn University at Montgomery, Montgomery, AL 36117. W.W. Cleland, Enzyme Institute, University of Wisconsin, Madison, WI 53706.

Chromium(III) monoammine complexes of ATP have been synthesized. Because of the chirality of the beta phosphorus and the position of the ammonia, a variety of isomers will result. Chromatographic methods have been developed which can separate these isomers. These methods include the use of a chiral column containing cycloheptaamylose, a reversed phase C18 column and a cation exchange column. With these methods, 13 isomers of the chromium(III) monoammine complex of ATP have been separated.



## Abstracts

POLY (4-CYCLOHEXYLBUTYL-1-METHACRYLATE): SYNTHESIS AND SOLUTION PROPERTIES. Jian Zhou and Jimmy W. Mays, Dept. of Chemistry, Univ. Ala. Birmingham, Birmingham, AL 35294.

Polymers having the same backbone structure but different side groups afford the opportunity to study the effect of the nature of various substituents on polymer properties. Polymethacrylates are perhaps the best class of polymers for use in such studies because of both the ease with which a broad range of methacrylate esters can be prepared and because of facile polymerization of the resulting materials. We have recently prepared and fractionated a new polymethacrylate, poly(4-cyclohexylbutyl-1-methacrylate) (PCBMA). The dilute solution properties and glass transition behavior of PCBMA will be reported and compared with results obtained for other polymethacrylates.

POLY(4-PHENYLBUTYL-1-METHACRYLATE): SYNTHESIS AND SOLUTION PROPERTIES. Yuan-Ju Chen, Shouyan Nan, and Jimmy W. Mays, Dept. of Chemistry, Univ. of Ala. Birmingham, Birmingham, AL 35294.

Poly(4-phenylbutyl-1-methacrylate) (PPBMA) was prepared by free radical polymerization in benzene at 50° C. The resulting polymers were fractionated using toluene and methanol as the solvent/nonsolvent system. These narrow molecular weight distribution PPBMA fractions were characterized using a combination of viscometry, size exclusion chromatography, and differential scanning calorimetry. The solution properties of PPBMA will be compared with those of other polymethacrylates. Glass transition behavior of these materials will also be discussed.

BROWNIAN DYNAMICS SIMULATION, Jeffry D. Madura, Department of Chemistry, University of South Alabama, Chem Bldg. Rm 223, Mobile, AL 36688.

A general purpose Brownian dynamics program has been developed. The program can calculate bimolecular diffusion-controlled rate constants, electrostatic free energy of binding, electrostatic fields, and the  $pK_a$  of titratable sites in proteins. This poster will present the methods used to perform such computations, describe the program's functionality and cite several applications utilizing the program.

## Abstracts

WEARING A TOP HAT TO CHEMISTRY CLASS. R. Glenn Murphy and Fred Gant, Dept. of Physical Sciences and Engineering, Jacksonville State University, Jacksonville, AL 36265.

The student enrollment in the sciences is declining steadily and the attitude toward the sciences is one of frustration and even hatred. By showing students that science can be entertaining as well as educational, the attitudes toward the sciences will become more positive. In the past two years, we have performed chemical "magic shows" for hundreds of students and the response has been outstanding. This talk will center on how to perform chemical demonstrations that will be entertaining as well as educational.

SECOND VIRIAL COEFFICIENT OF A FLEXIBLE POLYMER/POOR SOLVENT SYSTEM. Jianbo Li, Yunan Wan, and Jimmy W. Mays, Dept. of Chemistry, Univ. of Ala. Birmingham, Birmingham, AL 35294.

Light scattering measurements were conducted on near-monodisperse poly( $\alpha$ -methylstyrene) samples in cyclohexane at temperatures as much as 11.2°C below the theta temperature (36.2°C). The molecular weight range probed was from  $7.5 \times 10^4$  to  $1.1 \times 10^6$ . It was found that the second virial coefficient  $A_2$ , which reflects thermodynamic interactions, assumes larger negative values as molecular weight increases. These findings will be discussed and compared with prior experimental results on the system polystyrene/cyclohexane and with predictions of the two-parameter theory.

SOME DO'S AND DON'TS OF CHEMICAL DEMONSTRATIONS. Fred Gant and Glenn Murphy, Dept. of Physical Sciences and Engineering, Jacksonville State University, Jacksonville, AL 36265.

This paper will discuss the organization and presentation of chemical magic shows for the purpose of interesting students in the study of chemistry. The authors have presented shows to hundreds of students from the age of kindergarten to college chemistry classes and will discuss some experiments you will definitely want to avoid, as well as those which have been most successful.

## Abstracts

### GEOLOGY

EVOLUTION OF A METAMORPHIC INVERSION BETWEEN THE UPPER AND UPPERMOST ALLOCHTHONS, ULLSFJORD, ARCTIC NORWAY. Janet Coker and Mark G. Steltenpohl, Dept. of Geology, Auburn Univ., AL 36849-5305.

The Scandinavian Caledonides comprise a vertical stack of far-travelled east-directed thrust sheets emplaced during the early to middle Paleozoic. The contact between the Upper (Lyngen Nappe) and Uppermost (Tromso Nappe) Allochthons near Ullsfjord is marked by an inverted metamorphic gradient (IMG). Metamorphic grade in the footwall block (Upper Allochthon) increases from chlorite to sillimanite zone structurally upward approaching the contact. The overlying Uppermost Allochthon contains amphibolite- to eclogite-facies rocks. Structural complexity increases upward from simple bedding-cleavage relations through a strong transposition fabric into an amphibolite-facies gneissosity. Igneous intrusives also increase in abundance and type upward. Pillow lavas and graded and cross beds in the footwall units indicate right-way up. Low-grade metasedimentary units in the Upper Allochthon have a depositional contact with an underlying ophiolite complex. These metasedimentary rocks are reported to contain Late Ordovician-Early Silurian fossils, documenting post-Early Silurian metamorphism of the footwall block. The IMG herein is interpreted as having formed due to downheating. This requires that the Uppermost Allochthon also was emplaced and metamorphosed following the Early Silurian. Results have implications for terrane analyses, ophiolite obduction, and polyphase Caledonian tectonic evolution.

The Cahaba Lily: Its distribution and status in Alabama. L. J. Davenport, Department of Biology, Samford University, Birmingham, AL 35229.

The Cahaba Lily (Hymenocallis coronaria) is an emergent aquatic plant native to Alabama, Georgia and South Carolina. In Alabama, it is known from the Black Warrior, Cahaba, Coosa, and Tallapoosa river systems. It is restricted to relatively swift-flowing water at or above the Fall Line, where rock crevices trap the seeds. Leaves emerge from the substrate in mid-April; the three-inch broad white flowers appear from early May to mid-July, with peak flowering during late May. The inch-long seeds sink to the stream bottom and are swept into the crevices, where germination occurs. In the past, a number of populations have been extirpated by the building of dams; this threat continues, however, especially in the Locust Fork of the Black Warrior. Other current threats include siltation and the poaching of bulbs for horticultural use. The species is listed as Endangered on the unofficial state list, and is currently under review by the U. S. Fish & Wildlife Service.



## Abstracts

AN AUTOMATED, MICROCOMPUTER-BASED IMAGE-ANALYSIS SYSTEM FOR EVALUATION OF POROSITY IN HYDROCARBON RESERVOIRS Ralph L. Kugler, Geological Survey of Alabama, P.O. Box O, Tuscaloosa, AL 35486.

Pore and pore-throat systems dictate the storage capacity and fluid-flow characteristics of sandstone and carbonate hydrocarbon reservoirs. Routine porosity, permeability, and capillary-pressure analyses provide insight into the nature of pore systems. However, microscopic techniques are necessary to decipher the spatial distribution of pore types. Quantification of pore types during routine modal analysis using polarized, transmitted light microscopy is difficult due to particle/pore overlap and inconsistency in achieving consistent focus within the 30  $\mu\text{m}$  thickness of petrographic thin sections. These obstacles can be overcome by using backscattered-electron images (BSE) or by using blue or blue-violet light induced epifluorescence images of epoxy impregnated pores in polished thin sections. Digital gray-scale images produced by both techniques require minimal processing to obtain binary images of the pore system. Typically 15 to 25 images per sample at magnifications of 50 to 100X must be digitized to obtain a sufficient number of pores for statistical treatment of measurements. In order to facilitate collection, processing, and analysis of the large number of digital images required for investigation, a mouse-driven program was written in a macro language for a spreadsheet operating under a graphical user interface on a 486-based microcomputer. The macro controls microscope stage movement for collection of epifluorescence images; BSE images are transferred to the microcomputer from a minicomputer on a scanning electron microscope as 8-bit tag image file format (TIFF) files. Image acquisition, processing and measurement functions are controlled directly from the spreadsheet macro through dynamic data exchange. Area, perimeter, axis length, center of mass and fast fourier transform shape parameter measurements are collected routinely from images of the pore system. Several derived parameters are calculated from these primary parameters. Additionally, measurements are acquired from images produced as successive erosion/dilation cycles are applied to the original images in order to evaluate pore-throat systems. Processing of all images from a single sample requires 5 to 45 minutes, depending on the number and type of measurements desired. The macro allows unattended measurement and processing of several samples during a session.

THE LATE JURASSIC MANILA EMBAYMENT: TWO DISTINCT DEPOCENTERS? Steven D. Mann and David C. Kopaska-Merkel, Geological Survey of Alabama, Tuscaloosa, AL 35486-9780.

The Manila embayment is located in Clarke, Wilcox, Monroe, Baldwin, Mobile, and Washington counties in southwest Alabama. The embayment was an important site of Late Jurassic sediment deposition, and contained two distinct depocenters (based on analysis of Smackover thickness patterns). The northeasterly depocenter is centered in southeastern Clarke County; the southwesterly depocenter is centered under the four-corners area of Washington, Clarke, Baldwin, and Mobile counties. In both depocenters the Smackover attains in excess of 400 feet in thickness, whereas in the saddle between them, the Smackover thins to less than 200 feet. The Smackover Formation in the northeastern part of the Manila embayment contains substantial amounts of quartzose sandstone and sandy carbonate rock. By contrast, little or no sand is found in the Smackover in the southwestern depocenter. A prominent ridge ran from southwest to northeast across central Washington County during the Late Jurassic, separating the western part of the Manila embayment in the four-corners area from the eastern part of the Mississippi interior salt basin (western half of Washington County). The strongest evidence for the existence of this ridge is stratigraphic. Log signatures of Smackover strata on opposite sides of the inferred ridge are dissimilar. More tellingly, log signatures of the overlying Buckner Anhydrite Member of the Haynesville Formation are dramatically different. In the MISB, the Buckner contains between 100 and 400 feet of massive subaqueous anhydrite. The same interval in the southwestern part of the Manila embayment is dominated by massive halite. Wells on the same side of the putative ridge present similar aspects; closely spaced wells on opposite sides of the ridge do not.

## Abstracts

K-T BOUNDARY SANDS IN ALABAMA REVISITED: ADDITIONAL EVIDENCE FOR A NON-CATASTROPHIC SEA-LEVEL RELATED ORIGIN. Charles E. Savrda, Dept. of Geology, Auburn University, AL 36849-5305.

Thin discontinuous sand or sandstone bodies informally known as the "Clayton sands" occur near the K-T boundary at various localities in central and western Alabama. Two disparate genetic interpretations have been offered for these sands. Clayton sands have been attributed to (1) catastrophic tsunami deposition associated with a K-T boundary impact event (based on the extrapolation of interpretations made for similar K-T boundary sands in Texas) and (2) noncatastrophic transgressive infilling of incised valleys cut during a preceding sea-level lowstand (based primarily on sequence stratigraphic principles). The results of detailed ichnological and sedimentological studies of Clayton sand bodies exposed at Mussel Creek (central AL) and Moscow Landing (western AL) clearly refute the first interpretation and support the second. Local relief of basal surfaces and trace fossil evidence for drastic changes in substrate consistency of underlying strata indicate that considerable erosion occurred prior to deposition of the sands. Localized karstification of subjacent strata indicates that this erosion was subaerial. The nature of upper contacts indicates that sand bodies were truncated by erosion in a manner that is consistent with transgressive ravinement. Certain trace fossils, including Ophiomorpha, Thalassinoides, and small horizontal burrows, were clearly emplaced prior to cessation of sand deposition. These biogenic structures and physical sedimentary structures (e.g., tidal laminites) are indicative of noncatastrophic deposition in shallow marine and estuarine environments. The position and internal variability of sand bodies exposed at Moscow Landing were controlled by faulting that occurred prior to and contemporaneous with deposition.

INHIBITION OF ADENOSINE DEAMINASE WITH TETRACHLOROPLATINATE(II). Paul Muñoz, William S. Richardson, and John E. Teggin, Department of Physical Sciences, Auburn University at Montgomery, Montgomery, Alabama 36117.

Adenosine deaminase (ADA) (Adenosine Aminohydrolase, EC 3.5.4.4), found at particularly high levels in T-cells of various forms of acute lymphocytic leukemia, catalyzes the deamination of adenosine and deoxyadenosine to inosine and deoxyinosine, respectively. Certain heavy metals are known inhibitors. Platinum complexes are inhibitors of many enzymes, and several of these complexes are known anti-tumor agents. A search of the literature reveals that no study has been done on the inhibition of ADA by any form of platinum. By observing the catalytic activity of calf spleen ADA in the presence of varied concentrations of tetrachloroplatinate(II), we have determined that the complex ion is an active inhibitor of the enzyme. Assays of enzyme solutions that have been pre-incubated with different tetrachloroplatinate(II) concentrations demonstrate that ADA activity decreases with time of incubation as well as inhibitor concentration. This data suggests an inhibitor-enzyme complex forms over time to diminish the activity of ADA.



## Abstracts

GEOCHEMISTRY OF SALT DOME-HOSTED Zn-Pb AND Sr DEPOSITS, CENTRAL MISSISSIPPI. James A. Saunders and Peter A. Salpas, Dept. of Geology, Auburn University, AL 36849.

Zn-Pb and Sr mineralization at Hazlehurst and Tatum salt domes, Mississippi, occur in close proximity to present-day oil field brines containing Zn, Pb, and Sr, which suggests a genetic link between the brines and the cap rock mineral deposits. Na-Ca-Cl oil field brines from the Mississippi Salt Dome Basin comprise some of the best documented and most metal-enriched natural waters known, typically containing up to 2000 mg/l Sr, >100 mg/l Pb+Zn along with low concentrations of reduced sulfur (<0.1 mg/l). To test the hypothesis of metal-rich brine involvement in cap rock formation, the computer reaction-path program CHILLER was used to model chemical reactions between a typical Mississippi oil field brine and cap rock minerals in the presence and absence of bacterial-mediated sulfate reduction. In general, the geochemical models are capable of reproducing the "exotic" mineral suites present. At Tatum Salt Dome, where sulfate reduction apparently ceased late in the development of the cap rock, the modeling predicts the observed abundance of celestite, strontianite, and barite. Alternatively, modeling of hypothesized processes at Hazlehurst Salt Dome, where sulfate reduction was a long-lived process, predicts the observed mineral assemblage of Fe-Pb-Zn sulfides with calcite and the absence of Cu and Ag sulfides. Modeling results indicate that migration of metal-rich brines out of their host formations could lead to the formation of potentially economic deposits of Zn-Pb or Sr in the Mississippi Salt Dome Basin.

AN OVERVIEW OF THE AQUATIC INVERTEBRATE FAUNA OF THE CAHABA RIVER. Steven C. Harris, Geological Survey of Alabama, Tuscaloosa, AL 35486-9780.

The Cahaba River in central Alabama has long been recognized as one of the last major free-flowing rivers in the state. The river originates in the Valley and Ridge physiographic province north of Birmingham and traverses the East Gulf Coastal Plain entering the Alabama River near Selma. Despite the unique geologic features of the river the invertebrate fauna remains poorly studied. The mussels inhabiting the river have been recorded, beginning with the work of van der Schalie in the 1930's, but the gastropod fauna is not as well known. The only other non-insect group receiving any attention is the crayfishes which are the subject of an ongoing study by researchers at the University of South Alabama. While aquatic insects are the most diverse group of invertebrates in the Cahaba, only the caddisfly fauna is known in any detail. Species of other water quality indicative groups, including the stoneflies and mayflies, have been recorded from the river, but faunistic surveys are incomplete. Recent water quality monitoring work by the Geological Survey of Alabama, which included the collection and identification of invertebrates from the main channel and major tributaries of the Cahaba, provides a baseline for future studies.



## Abstracts

### TECTONIC VS. EUSTATIC CONTROLS ON ORDOVICIAN DEPOSITION IN THE ALABAMA APPALACHIANS. D. Joe Benson, Department of Geology, University of Alabama, Tuscaloosa, AL 35487

A sedimentary sequence is the product of the interaction between eustatic sea level fluctuation, tectonic subsidence or uplift, and sedimentation rate. Considerable attention has been given in the past decade to the effects of eustatic sea level fluctuations on sedimentary sequences, with relatively little attention given to tectonic influence. The Middle Ordovician sequence in the Alabama Appalachians illustrates the influence of both eustatic sea level and tectonic activity on sedimentary deposition. The Middle Ordovician sequence was deposited over a major regional unconformity, the post-Knox unconformity, that truncates shallow marine carbonates throughout the Alabama Appalachians. Middle Ordovician deposition was initiated during middle Whiterockian time, as a result of a combination of eustatic sea level rise and downwarping of the southeastern margin of the North American continent, associated with the early stages of Taconic orogenic activity. Earliest Middle Ordovician deposits are peritidal carbonates that onlap the Post-Knox unconformity from southeast to northwest. Continued loading of the margin of the continent led to rapid evolution of a deep-water basin to the southeast and the concurrent development of a peripheral bulge in the vicinity of what is now the Birmingham anticlinorium. Peritidal carbonates to the southeast pass upward into shallow ramp carbonates; deep-ramp mixed carbonate/clastic deposits; and ultimately basinal organic shales. As the deep-water basin evolved to the southeast, shallow ramp carbonates onlapped northwestward. By late Whiterockian time, most of northern Alabama with the exception of the peripheral bulge was inundated. Continued eustatic sea level rise led to a progressive increase in water depth and ultimately inundated the peripheral bulge during early Mohawkian time.

### UPPER SILURIAN STROMATOPOROIDS IN ALABAMA. Carl W. Stock, Department of Geology, University of Alabama, Tuscaloosa, AL 35487-0338.

Traditionally, the Red Mountain Formation of Alabama has been thought of as Early Silurian in age; however, work by B.A. Ferrill and coauthors in the early and mid-1980s documented a portion of the Red Mountain that is Late Silurian (Pridoli) in age. This subunit is geographically restricted to southern Jefferson County. Stromatoporoids are found in the Pridoli beds at a chert pit in Sparks Gap, and near the mill pond in Tannehill State Park. Preliminary examination of the stromatoporoid fauna reveals a typical assemblage of Upper Silurian genera: *Petrostroma*, *Actinostromella*, *Parallelostroma*, *Stromatopora*, and possibly *Syringostromella*. Unfortunately, many of the specimens are not well preserved, in that recrystallization and calcite twinning have occurred. Other fossils occurring along with the stromatoporoids are rugose, tabulate, and heliolitid corals, bryozoans, brachiopods, ostracodes, trilobites, and pelmatozoan echinoderm columnals. Nearly all of the large fossils show evidence of having been transported to the site of deposition. Although the Pridoli Red Mountain has been correlated with the Cobleskill Member of the Rondout Formation of New York, based on the co-occurrence of the brachiopod *Eccentricosta* and the ostracode *Welleropsis*?, the two lithostratigraphic units do not share any stromatoporoid species. Nor are there any species in common with the Pridoli portion of the Keyser Formation in Virginia known at the present time. In this respect the Pridoli part of the Red Mountain Formation is more like stromatoporoid-bearing strata of eastern Europe (e.g., Estonia and the Podolia region of the Ukraine), than it is with more northern portions of the Appalachians.

## Abstracts

**MAJOR AND TRACE ELEMENT CHARACTERISTICS OF THE WHATLEY MILL GNEISS, PINE MOUNTAIN TERRANE, ALABAMA.** Neil Daniell, Peter A. Salpas, Thomas J. Carrington, and Dana L. Booker, Dept. of Geology, Auburn University, AL 36849-5305.

The Whatley Mill Gneiss (WMG) constitutes a major exposure of the Pine Mountain massif in eastern Alabama. Over 190 meters of stratigraphic thickness of the WMG are exposed in a creek at Chewacla Park, Auburn, Alabama. Based on appearance in this outcrop the WMG can be divided into two distinct lithologies. The first is an augen gneiss (AG) which is the type lithology for the WMG. The second is a fine-grained gneiss (FG), either devoid of augen or containing some stretched augen, that occurs sporadically within the WMG as zones of variable thicknesses parallel to the foliation of the WMG. The rocks of the FG bands are mylonitic and appear to have been created in shear zones within the AG. The bands of FG are more prevalent near the stratigraphic middle of this exposure of WMG. The FG samples exhibit larger ranges in concentrations of most elements (e.g., to name a few  $\text{SiO}_2$ : 51.6-79.9 wt%; FeO (total Fe): 1.2-14.2 wt%;  $\text{K}_2\text{O}$ : 0.07-1.26 wt%; Sc: 3.3-28.5 ppm; La: 16.9-113.2 ppm; Yb: 0.61-5.21 ppm; Ta: 0.065-1.32 ppm) when compared to AG samples ( $\text{SiO}_2$ : 62.0-66.4 wt%; FeO (total Fe): 4.9-8.0 wt%;  $\text{K}_2\text{O}$ : 3.33-4.35 wt%; Sc: 11.0-17.1 ppm; La: 49.1-76.6 ppm; Yb: 2.12-3.08 ppm; Ta: 1.09-1.74 ppm) an observation that is interpreted to indicate that deformation of the original AG was nonuniform resulting in incomplete redistribution of the chemical elements during shearing.

**EVOLUTION OF A METAMORPHIC INVERSION BETWEEN THE UPPER AND UPPERMOST ALLOCHTHONS, ULLSFJORD, ARCTIC NORWAY.** Janet Coker and Mark G. Steltenpohl, Dept. of Geology, Auburn Univ., AL 36849-5305.

The Scandinavian Caledonides comprise a vertical stack of far-travelled east-directed thrust sheets emplaced during the early to middle Paleozoic. The contact between the Upper (Lyngen Nappe) and Uppermost (Tromso Nappe) Allochthons near Ullsfjord is marked by an inverted metamorphic gradient (IMG). Metamorphic grade in the footwall block (Upper Allochthon) increases from chlorite to sillimanite zone structurally upward approaching the contact. The overlying Uppermost Allochthon contains amphibolite- to eclogite-facies rocks. Structural complexity increases upward from simple bedding-cleavage relations through a strong transposition fabric into an amphibolite-facies gneissosity. Igneous intrusives also increase in abundance and type upward. Pillow lavas and graded and cross beds in the footwall units indicate right-way up. Low-grade metasedimentary units in the Upper Allochthon have a depositional contact with an underlying ophiolite complex. These metasedimentary rocks are reported to contain Late Ordovician-Early Silurian fossils, documenting post-Early Silurian metamorphism of the footwall block. The IMG herein is interpreted as having formed due to downheating. This requires that the Uppermost Allochthon also was emplaced and metamorphosed following the Early Silurian. Results have implications for terrane analyses, ophiolite obduction, and polyphase Caledonian tectonic evolution.



## Abstracts

**40Ar/39Ar THERMOCHRONOLOGY AND TECTONIC EVOLUTION OF THE EASTERNMOST ALLEGHANIAN-VARISCAN OROGEN, SUDETY MOUNTAINS, POLAND.** M.G. Steltenpohl, Dept. of Geology, Auburn Univ., Auburn, AL 36849. Z. Cymerman, Panstwowy Instytut Geologiczny, ul. Jaworowa 19, 53-122 Wrocław, Poland. M.J. Kunk, U.S.G.S., Reston, VA 22092.

The Sudety mountains are the most northeastern part of the Alleghanian (North American)-Variscan (European) orogenic system and are characterized by mylonite zones flanking various crystalline terranes. The Snieznik complex is a Caledonian or earlier (?) basement massif that was deformed and metamorphosed during the Variscan orogeny. Shear sense along moderate-dipping mylonite zones within and flanking the Snieznik complex has been determined. Deformation is characterized by two main kinematic events, early north-directed thrusting and right-slip transpression. Thrusting resulted in extreme crustal thickening and associated eclogite-facies metamorphism. Permian age red bed deposits document uplift and exposure of parts of the Snieznik complex during lithospheric extension. Sm/Nd isotopic age dates on Snieznik eclogites are 353, 337, and 330 Ma and record the time of the metamorphic peak. 40Ar/39Ar isotopic age dates on hornblende (338 and 332 Ma), muscovite (329 and 329 Ma), and biotite (328 Ma) reflect cooling through the Ca. 500, 350, and 300°C isotherms. This implies rapid cooling from eclogite-facies temperatures (estimated at 850 to 720°C) to 300°C (biotite closure). Rocks of the Snieznik complex thus record Early Carboniferous crustal thickening and concomitant right-slip ductile movements followed by Late Carboniferous to Permian normal faulting. This tectonic development is similar to that becoming recognized within the Alleghanian Piedmont of the southernmost U.S. Appalachians, suggesting a pattern recognizable in the two termini of this ancient Pangaea spanning mountain system.

**MINERAL RESOURCES OF MARSHALL COUNTY, ALABAMA.** Lewis S Dean, Geological Survey of Alabama, P.O. Box O, Tuscaloosa, AL 35486

Marshall County, located in the Appalachian Plateau region of northeastern Alabama, contains deposits of chert, limestone, sandstone, clay and shale, coal, and sand and gravel. These mineral resources occur throughout the county in association with several different sedimentary geologic formations of Ordovician, Mississippian, Pennsylvanian, and Quaternary age. Large-scale mining operations were first carried out in 1935-39 in which the Mississippian Bangor Limestone, and Quaternary sand, gravel, and clay were mined during construction of Guntersville Dam. The Bangor Limestone has good physical and chemical characteristics for industrial and construction uses and has been quarried at several sites in the county. Since 1970, the average annual production of Bangor Limestone has been 470,000 tons, which was used in construction. A 30-foot section of high-calcium (>96% CaCO<sub>3</sub>) Bangor was quarried from 1943-45 from an underground operation for the production of calcium carbide used in the manufacture of synthetic rubber (neoprene). Residuum and weathered conglomerate and sandstone near the base of the Pennsylvanian Pottsville Formation along the Brindley Mtn. escarpment is quarried to produce specification quartz sand and gravel for construction uses. Well-indurated quartzose sandstone and conglomerate in the Pottsville on the Sand Mtn. plateau has been quarried for building stone and riprap. Pottsville shales from Marshall County with uniform physical and firing characteristics are utilized as blending clay in the manufacture of brick in adjacent Madison County. Since 1971, there has been an average annual production of 35,000 tons of shale. Residuum derived from the Mississippian Fort Payne Chert along the flanks of the Sequatchie anticline is a low-value commodity quarried for road base and fill material.



## Abstracts

CAVERN DEVELOPMENT IN POTTSVILLE SANDSTONE, BIRMINGHAM, ALABAMA.  
Denny N. Bearce and Michael J. Neilson, Dept. of Geology, Univ. of Ala.  
at Birmingham, Birmingham, AL 35294

Localized ground surface collapse on the property of Our Lady of Sorrows Monastery, Irondale, Alabama, has recurred during the past two decades despite repeated soil fillings. The property lies on a dip slope near the crest of Flat Ridge, and is underlain by sandstone of the Pennsylvanian Pottsville Formation. Surface collapse developed from a small, shallow cavern in sandstone overlain by about 1.5 meters of soil.

The cavern roof is a single thick bed of hard, massive-bedded sandstone, dipping gently southward and overlain by soil. The cavern is developed in thin-bedded, extensively weathered, friable sandstone. Maximum cave height is about .57 meters. This height decreases to about 15 centimeters over a distance of 9 meters northeastward from the point of surface collapse. Southwestward the cavern maintains sufficient height for crawling over a distance of 7.5 meters, and then turns abruptly southeastward. Its extent from that point is unknown. The cavern maximum width is about 3 meters.

Northwest and northeast striking vertical joints control the trend of the cavern, and joint block subsidence is evident in the cavern roof. Surface runoff has been concentrated in a shallow swale extending southeastward downslope from a highway at the crest of Flat Ridge to the point of surface collapse. The swale is evidently joint-controlled, and runoff drains through open joints, scouring loosened sand grains. The cavern floor is coated with ripple-marked sand.

Different weathering response of roof and wall rock results from different bed thickness, joint spacing, and lithic grain content. Decay of the lithic grains is more complete in the wall rock.

**GEOLOGIC AND HYDROLOGIC INVESTIGATIONS OF CAVES IN MADISON COUNTY, ALABAMA.** Karen F. Rheams and Paul H. Moser, Geological Survey of Alabama, P.O. Box O, Tuscaloosa, AL 35486.

The Geological Survey of Alabama in cooperation with the U.S. Fish and Wildlife Service has recently been involved in a multidisciplinary study to investigate the physical parameters that affect the occurrence of the rare and endangered Alabama cave shrimp. Although geologic and hydrologic investigations for this study have been concentrated in the areas surrounding Shelta Cave in northwest Huntsville and Bobcat Cave on Redstone Arsenal property, over 100 caves in Madison County have been evaluated for geologic and hydrologic conditions and biologic data. Ground-water movements are determined by tracer-dye studies. Potentiometric surface maps indicate a southerly ground-water flow and the recharge areas for Shelta and Bobcat Caves appear as large, irregular ellipses extending to the north. Land use in the recharge areas is dominated by a combination of urban, pasture, unused, forest, and agriculture. Correlations between local and regional lineaments, fractures, and cave orientation patterns indicate dominant northeast and northwest trends for lineaments and a dominant north-south trend for major cave passages. To evaluate ground-water quality, water samples from significant caves within the study area were analyzed on a quarterly basis for over 30 chemical constituents and parameters. Divergent water-chemistry trends for samples from Shelta and Bobcat Caves indicate no direct hydrologic connection between these two sampling points. Water-quality data for a 10-year period were compiled for wells in the vicinity of Shelta and Bobcat Caves to develop trends for the analyzed parameters and chemical constituents. Comparison of long-term water-quality trends to recent water-quality data for the caves indicate probable deterioration in the ground-water quality of Shelta Cave that may have affected cave fauna. Investigations have been preliminary thus far, but additional geologic, hydrologic, and biologic work is currently in progress.

## Abstracts

### FORESTRY, GEOGRAPHY, CONSERVATION, AND PLANNING

ASSESSING GUATEMALA'S REMOTE SENSING DATA NEEDS FOR AGRICULTURAL ESTIMATION PURPOSES. David R. Hicks, Dept. of Geography, Auburn University, Auburn University, AL 36849-5224.

The Department of Geography at Auburn University recently provided assistance to Guatemala's Ministry of Agriculture in the design of a computerized Geographic Information System (GIS) to be used for crop condition assessment and harvest estimation for key agricultural crops. Secondary applications include agricultural land use and environmental monitoring. The proposed GIS, to be possibly funded by the U.S. Agency for International Development (USAID), requires careful selection of remotely sensed data for the GIS cartographic base. A pilot project area was established in southwestern Guatemala that exhibits great physiographic and crop type/landholding size diversity which is representative of a much larger area. Large-scale row crops such as cotton and sugar cane are grown in tropical lowland areas and are ideally studied by Landsat Thematic Mapper imagery. However, Landsat data lacks sufficient spatial resolution to be useful elsewhere in the pilot project area which is dominated by small-scale intensive highland agriculture including wheat, black bean, and vegetable cultivation. The effectiveness of alternative sensors such as those aboard the French SPOT satellite, or color infrared air photos therefore need to be evaluated for input into the GIS. The study focuses on describing and analyzing these remote sensing data sources and their potential role in the larger GIS project.

CRITICAL THINKING IN GEOGRAPHY THROUGH THE USE OF QUESTIONING, INTEGRATION OF SUBJECTS, AND COOPERATIVE LEARNING. Emily Patterson, Dept. of Geography, Univ. of N. Ala., Florence, AL 35632-0001.

The America 2000 educational goals were adopted by President Bush and the nation's governors in 1990. This report will ensure that America's students will leave their perspective grades with demonstrated competency in the disciplines of English, mathematics, science, history, and geography. Also, every student will have the opportunity to learn how to think critically and analytically so that they may be better prepared for responsible citizenship, future learning experiences, and productive employment in the modern society of today and the future. Geography is the perfect medium for implementing critical thinking skills, questioning skills, and cooperative learning techniques since geography can be integrated with all other disciplines such as mathematics. As educators and professionals, a top priority of classroom teaching must be to help our students to become independent thinkers and lifelong learners.

## Abstracts

THE IMPACT OF DROUGHT (1980-1990) ON THE CHATTAHOOCHEE WIREGRASS REGION OF ALABAMA. Michele Masucci and Richard Perritt, Department of Geography, Auburn University, Auburn Alabama, 36849

The period 1980-1990 highlights one of the Southeast's most severe drought episodes. The Chattahoochee River Basin Region was seriously impacted, both environmentally, in terms of reduced flow and water quality, and economically, as shortages among competing uses of water led to a range of problems, such as reduced hydropower operations, crop failure, increased reliance on groundwater for irrigation, and implementation of navigation windows to maintain a minimum level of transportation service in the lower part of the basin. Alabama responded to this crisis by initiating a drought contingency planning process, and is currently undergoing a complete revision of water planning policies in conjunction with the Army Corps of Engineers' Chattahoochee reallocation study.

These drought episodes provide a unique record of drought management, especially pertaining to a predominantly agricultural region. The Chattahoochee study also provides a useful analogy for considering the broader concern of global warming and its impacts on local areas. By identifying mitigating management practices for actual drought episodes, future management and planning processes may reflect this record. This paper will discuss a framework for considering responses among water managers, both in basin planning and agriculture. The concept of eliciting responses draws on the natural hazards research from geography and on economic cost and price factors based on resource economics. The natural hazards approach allows for the identification of the range of management responses among a variety of actors; cost and price provide a means of comparing water uses.

CLASSIFYING TM DATA USING THE ENVIRONMENTAL MONITORING AND ASSESSMENT PROGRAM: LAND CLASSIFICATION (EMAP-LC) APPROACH. Amy Smallwood and Leigh Thompson, Department of Geography, University of North Alabama, Florence, Alabama 35632-0001.

Due to the controversy surrounding the misuse of the environment, the Environmental Protection Agency (EPA), has deemed it necessary to implement a new system of land classification for remotely sensed data. This new classification scheme is called the Environmental Monitoring and Assessment Program Land Classification (EMAP-LC). EMAP is being developed to monitor status and trends in the conditions of the Nation's ecosystems. EPA's EMAP classification is in the pilot study stage, but it is hoped that it will become the standard for TM data classification in monitoring ecosystems. The purpose of this study is to apply the EMAP classification system to TM data leaf-off scenes in 1986 and 1990, over Northwest Alabama to determine EMAP's advantages compared to other classification systems.



## Abstracts

FABULOUS FORESTS OF THE SOUTH. Wilbur B. De Vall, Proxy Services Ltd., Auburn, AL 36830.

Long before European settlers reached America, the Indians knew the life-sustaining value of the forest. They relied on the self-renewing stands of trees for food, shelter, fuel, transportation, and medicine. These same forests represented danger and hard work. Trees had to be cut down and cleared away to make room for fields and settlements. Logs were burned. While tall trees were prized as masts for sailing ships, wood also fueled river boats and trains. Through the 1920's, southern forests helped build the country by providing wood for construction. By the 1930's, previously forested lands were considered a disaster area. Soil best suited for growing trees had been cleared for a few harvests of cotton and corn. Abandoned lands washed away and gullies meandered across these deserted fields. These cutover forests came back with fire protection and proper management. Today, southern forests help pay taxes on a multi-billion dollar industry and provide more than 700 thousand jobs. Forested lands, with their lakes and streams, support millions of wildlife. Wildflowers, scenic drives, and camping sites are but other dividends of the managed forest. Seventy percent of southern woodlands is owned by individual owners in small tracts of less than 5,000 acres. Research, including genetics, has provided trees of rapid growth, straight boles, and quality wood fiber. The continued educational activities of the states, industry, and colleges have made management of the south's fabulous forests both productive and aesthetic to the benefit of mankind.

FREQUENCY AND DURATION OF NORMAL WEATHER. Peter T. Soulé, Dept. of Geography, Univ. of Ala., Tuscaloosa, AL 35487-0322.

The primary purpose of this paper is to examine the spatial patterns of average climatic events in the contiguous United States. Data examined are monthly values of the Palmer Drought Severity Index (PDSI), and standardized scores (z-scores) of temperature (TEMPZ) and precipitation (PREZ) for all climatic divisions in the contiguous United States. Average climate events are defined as periods of at least 3 or 6 consecutive months with index (PDSI, TEMPZ, PREZ) values within small ranges of zero (e.g. +0.5 to -0.5 standard deviations). Isoline maps showing the total number and average length of average climatic events occurring during the period 1959-1988 are presented for each index. Overall, patterns of frequency and duration of average climatic events exhibit a low degree of spatial variability. The most distinct patterns are found on the precipitation maps, with comparatively high frequency and duration of average events in the western United States.

## Abstracts

TVA's LAND PLANNING PROCESS. Robert W. Aldridge, University of North Alabama, Florence, AL 35630.

The following is based on information gathered from the reservoir plans for Pickwick, Wheeler, and Chickamauga reservoirs, as well as direct information from land use specialists at TVA. The Tennessee Valley Authority's reservoir system includes more than 10,000 miles of shoreline and approximately 300,000 acres of public land. These lands have been used for parks, industry, wildlife management, and recreation, as well as to serve specific needs of local communities. Conflict between private and public use often results in uneconomic and/or environmentally disturbing practices. Subsequently, TVA has developed individual land plans for the reservoirs in the TVA system. These plans present reservoir-specific management objectives for reaching TVA's general land management goals. The plans designate reservoir lands for a variety of single and multiple land uses, guided primarily by public input, TVA land policies and management objectives, and the capability of the land to support various uses. The plans provide data and analysis in sufficient detail to prepare environmental assessments or land use reviews, and they provide a facility for recording and updating environmental conditions, land use, and land rights on TVA lands. TVA's Land Resources Division has begun development on an Automated Land Information System (ALIS). According to land use specialists in the Land Resources Division, ALIS, as planned, will improve the accuracy and currency of maps, as well as improve the efficiency and work environment of the land use specialists.

NORTHWEST ALABAMA TRANSIT ASSOCIATION STUDY. Priscilla Holland, Dept. of Geography, Univ. of N. Ala., Florence, AL 35632-0001.

Access to public transportation is becoming an important issue in American society. At one time in our history, people could hail an intercity bus in almost any town and travel to other places to greet friends, conduct business, or to move in search of better opportunities. Intracity travel by public transportation was equally available until the advent of the personal automobile and lower cost air travel. Since that time, public transportation has decreased in availability and in places served. The elderly population and those without personal transportation have been affected substantially. The purpose of this study is to provide the staff of NATA and public officials of the individual counties with a base for a transportation development plan. The study includes an overall view of the NATA system within the counties of Lauderdale, Colbert, Franklin and Marion. Each county will receive separate coverage in order to provide information for developing individual Transportation Development Plans (TDP). The results of this study show a systematic examination of all facets of NATA from the conceptual foundation, through the design, funding and implementation of daily transportation activities. The information gained from this study provides the foundation for future planning and projected growth of the system.

## Abstracts

Northwest Alabama Transit Association Preventative Maintenance Study. Gail Clemons, Department of Geography, University of North Alabama, Florence, Alabama.

This study, funded by the Northwest Alabama Council of Local Governments (NACOLG) as an extension of the Northwest Alabama Transit Association Study (NATA), was designed to determine the most economical alternative available for maintaining their fleet of vans.

Two data bases were developed from invoices provided by NACOLG. One data base contains information of service work such oil changes, brakes, parts, and labor while the other contains cost amounts for replacement and service of tires. Both contain charges accumulated over the past three years. However, for a cost analysis, only data from October 1, 1990 through June 15, 1991 was utilized.

A total cost was provided to NACOLG along with the cost of an average trip to the garage. In comparing costs for contracting the service to a local car dealership as opposed to employing an in-house mechanic, a decision was made to do the work in-house. Savings were shown to affect not only areas of service but the amount of down time for the vehicles.

To verify the findings of this study, an on-going analysis of costs savings to NATA will be monitored by the Geographic Research Center at the University of North Alabama.

MAP CLASSIFICATION BY MAP FUNCTION. Thomas F. Baucom, Dept. of Geography/Anthropology, Jacksonville State University, AL 36265

Most authors of cartography texts indicate that flat maps may be classified by function into one of two categories, either as general purpose (reference) maps or special purpose (thematic) maps. Few cartographers suggest that more than two functional classes exist. On the other hand, surveys suggest that students have difficulty in correctly classifying an assortment of flat maps into just two classes but less problems in grouping maps into three functional categories. It is proposed that flat maps may be described as having either a singlely orientative purpose, a dominantly measurative purpose, or a basically statistical purpose. Orientative maps show where things are so that we may orient ourselves with respect to the location of map phenomena. Measurative maps are those that also provide orientation but additionally include information to permit us to precisely measure the geometry of map phenomena. Statistical maps are maps that not only provide orientation but also allow us to compare the magnitudes of some geographical distribution.



## Abstracts

TRENDS IN THE SPATIAL STRUCTURE OF CHINA'S INDUSTRIAL ECONOMY.  
Jeffrey P. Richetto and James Whitlam, Department of Geography,  
University of Alabama, Tuscaloosa, AL 35487.

Since the death of Mao Tse-tung in late 1976, China and its policies have undergone profound changes. Mao and his followers had for years insisted upon "uninterrupted revolution", giving priority to ideological and social transformations aimed at achieving an egalitarian society. Since 1977, China's leaders have shifted priorities and reoriented policies in far reaching ways, stressing the need to establish political stability and to accelerate national and international as opposed to provincial economic growth. In particular, provincial autonomy and the insulating effects of ministerial hierarchies meant that China's economy was divided into a large number of subeconomies each more or less independent. With the establishment of new reforms, however, China's once provincial-based economy will continue to transform into an integrated national economy poised for international trade and competition. To what extent the new reforms have facilitated this transformation of China's industrial economy forms the basis for this paper. In particular, the study examines the structural and spatial trends in China's industrial economy with an emphasis on the post-reform era. The nature, extent, and geographic dimensions of China integrating its historically segmented provincial industrial economy into a unified national market are explored.

BOTANICAL EVIDENCE FOR THE AGE OF OXBOW LAKES. David Shankman,  
Dept. of Geography, Univ. of Ala., Tuscaloosa, AL 35487

Roland Harper hypothesized in 1912 that the minimum age of an oxbow lake could be estimated by determining the age of the oldest bald cypress (Taxodium distichum). He based this hypothesis on his observations that bald cypress is usually absent along the banks of large streams but typically is one of the dominant species along the margins of oxbow lakes indicating that regeneration begins only after the channel cuts off. Oxbow lakes of a known age along the Hatchie River in western Tennessee were examined to determine how bald cypress ages corresponded to the cutoff dates. Initial colonization 60-80 years after cutoff indicates that the oldest individuals can be aged to determine the minimum age of oxbow lakes as Harper hypothesized. Also, bald cypress ages can be used to estimate the actual age of the oxbow lake with an error of no more than a few decades by adding 60-80 years, the time between cutoff and initial bald cypress colonization, to the age of the oldest bald cypress.

## Abstracts

GEOGRAPHY OF THE SENATE VOTE ON THE CONFIRMATION OF CLARENCE THOMAS.  
Gerald R. Webster, Dept. of Geography, Univ. of Alabama, Tuscaloosa,  
AL 35487.

The Senate vote on the confirmation of Judge Clarence Thomas to the United States Supreme Court included the ballots of 100 senators from 50 diverse and geographically dispersed states. Were there distinct geographical, political and cultural patterns underlying the spatial distribution of Senate votes for and against the confirmation of Judge Thomas? This paper examines four hypotheses pertaining to the impact of political party, race, electoral section and historic support for womens' issues on each Senator's vote. It finds that while party affiliation was the most significant determinant of how Senators cast their ballots, race, political culture and historic support for womens' issues were also associated with the pattern of Senate voting.

TORNADO OUTBREAK OF 3-4 APRIL 1974: AN ALABAMA PERSPECTIVE. John B. Bounds, Department of Geography, University of Alabama, Tuscaloosa, AL 35487.

The tornado outbreak of 3-4 April 1974 was an anomalous event in Alabama, particularly with respect to tornado-caused deaths and injuries. The frequencies of tornado-related deaths and injuries deviate significantly above the mean at the .05 level of significance, although the frequency of tornadoes for that year is statistically normal. Omitting the data which represents the event of 3-4 April 1974 reveals that 1974 would have been a below-normal year in terms of tornado-related deaths and injuries, with a tornado frequency closely approximating the mean for the entire data set.

"MENNONITES" OF ETHRIDGE: A CULTURE IN TRANSITION.  
Jon Kyle Ezell, University of North Alabama, Florence,  
Al 35632.

As a result of a medium-scale migration from their native Pennsylvania in 1944, a substantial Amish community emerged in Ethridge, in southern Tennessee. Known locally as "Mennonites", the Amish insist on primitive ways of living in all forms. The spatial pattern of their community creates a tight-knit environment that helps to preserve their culture. But increasingly, the once secluded community is faced with an infiltration of non-Amish residents, and a wave of interested tourists. The Amish must now find new methods of coping with these problems to survive culturally and economically.

## Abstracts

### PHYSICS AND MATHEMATICS

FLUORESCENCE OF DNA: INDICATIONS OF STRUCTURAL DYNAMICS. Kervin O. Evans, Daguang Xu and Thomas M. Nordlund, Dept. of Physics, University of Alabama at Birmingham, Birmingham, AL 35294.

2-Aminopurine free base (2AP) absorption and fluorescence excitation and emission spectra in a series of solvents have been measured to assess effects of solvent polarity. Temperature-dependent spectra of the base specifically incorporated into a DNA decamer [CTGA(2AP)TTCAG]<sub>2</sub> [1] have been determined to evaluate effects of helix structural change on spectra.

1. Emission spectra of 2AP red-shift in solvents of higher dielectric constant  $\epsilon$ .
2. Excitation spectra of the free base red-shift with increasing  $\epsilon$ , except in water.
3. A change in dipole moment of 2.6 Debye upon excitation is obtained.
4. Attachment of ribose or 2'-deoxyribose causes a 2 nm redshift of the emission spectrum of 2AP in water. Little change occurs in the excitation peak or yield.
5. The fluorescence excitation spectrum of [CTGA(2AP)TTCAG]<sub>2</sub> shifts to the blue when the helix melts, while the emission spectrum is unchanged.
6. The melting temperature of the decamer, whether measured by absorption of normal bases, absorption of 2AP, and fluorescence of 2AP, is the same.
7. Transient excursions of the 2AP base to the outside of the helix [2] should be accompanied by fluorescence spectral shifts.

[1] Synthesized by Prof. L.W. McLaughlin of Boston College.

[2] T. Nordlund, S. Andersson, L. Nilsson, R. Rigler, A. Gräslund, & L. McLaughlin (1989) *Biochemistry* 28, 9095-9103.

ZEEMAN EFFECT IN INFRARED RADIO FREQUENCY DOUBLE RESONANCE SPECTROSCOPY. Abdalla M. Darwish, Dept. of Physics, Univ. of Ala., Tuscaloosa, AL 35487.

Zeeman studies of IRRFDR signals for H<sub>2</sub>CS are being carried out with fields between 1 and 6 kG. So far one IRRFDR signal has been observed when pumped with a CO<sub>2</sub> laser. This was the first use of the Zeeman effect to study line splitting. The components were resolvable at 5 kG. Optoacoustic measurements of H<sub>2</sub>CS have also been performed and the pump offsets of the new lines have been measured. These experiments will be used to make assignments and improve the molecular constants for H<sub>2</sub>CS.



## Abstracts

CRYSTAL GROWTH OF ORGANIC NONLINEAR OPTICAL MATERIALS USING BRIDGMAN-STOCKBARGER TECHNIQUE\*. M.D. Aggarwal, W.S. Wang Dept. of Physics and K.J. Chang Dept. of Chemistry, Alabama A&M University, Normal, Al 35762

Organic nonlinear optical materials are getting increasing attention in recent years. These organic compounds exhibit extremely large nonlinear optical responses, in many cases by orders of magnitude larger than most known inorganic compounds. They also offer flexibility of molecular design, an intriguing possibility of "tailoring" nonlinear optical properties through organic chemistry. In the present paper, an attempt has been made to grow these crystals, viz., 2-methyl-4-nitroaniline (MNA) and benzil from melt using Bridgman Stockbarger Technique. A modified version of the two zone constant temperature furnace for temperatures upto 250°C has been designed and fabricated along with the ampoule lowering mechanism. Constant temperature has been achieved by circulating silicon oil in the two zones using Neslab temperature controller. Purification has been accomplished by recrystallization and physical vapor transport. This has been found to be the most important step in the growth process.

\* Work supported under NASA Grant NAG8-125 and NSF project RII-8802971

PRELIMINARY RESULTS FROM A PHOTODIODE LIGHT DETECTOR FOR SCINTILLATORS. C. Merrill Jenkins, R. Kent Clark, Dept. of Physics, Univ. of South Alabama, Mobile, AL 36688.

Scintillator detectors are commonly used in high energy physics to detect the passage of charged particles. These detectors are fast (commonly in the nano-second regime) and properly configured counters are used to commence the read out of other types of detectors that have better position resolution but have a slower response time. Typically, the light detection device used in conjunction with a scintillator is a photomultiplier tube which converts the light to an electronic pulse. These devices are quite large and must be placed in region of low magnetic fields. In addition, a voltage divider (base) is needed to apply proper voltage to the multiple stages of the photomultiplier. Often light guides are used to ship light from the scintillator to the photomultiplier/base assembly. We are investigating the feasibility of using photodiodes as an alternative light detector. Photodiodes are much smaller than photomultiplier tubes and the signals are shipped out via small wires. Photodiodes do require an amplifier. A description of the detector development laboratory, how photodiodes work, and the configuration of photodiode on a scintillator will be presented. Scintillators with photomultipliers and photodiodes will be compared using cosmic rays. Preliminary results include the plateauing process of the photomultipliers, and signal shapes as observed from scintillators with a photodiode detector. A discussion of future laboratory upgrades and plans will also be presented.

## Abstracts

STRESS DEPENDENCE OF THE GRUNEISEN GAMMAS :  
APPLICATION TO SOLID SILVER BROMIDE. Iyotirmay, Space Power  
Institute, Auburn University, AL 36849 and P.C. Sharma, Department of  
Physics, Tuskegee University, Tuskegee, AL 36088.

The Gruneisen parameter is an important quantity in the study of anharmonic, thermal, dielectric and elastic properties of solids. In the present work, a new equation has been derived which relates the isothermal pressure derivatives of the Gruneisen parameter with those of phonon velocities and thermal conductivities. The advantage of the work over previous technique is that the new method does not require the knowledge of the absolute values of the phonon velocities and thermal conductivities. Using the current technique for the first time, the stress dependent Gruneisen parameter has been determined.

This work was supported by the Strategic Defense Initiative Organization's Office of Innovative Science and Technology (SDIO/TNI) through contract number DNA001-90-C-0127 with the Defense Nuclear Agency.

DISCRETE MATHEMATICS VIA SPREADSHEETS. James M. Cargal,  
Department of Mathematics, Troy State Univ. in  
Montgomery, Montgomery, AL 36103.

Spreadsheets can be applied to many mathematical areas. However, they are particularly suited to doing discrete mathematics. Spreadsheets can be quite efficient for recursive algorithms and compare favorably with standard programming languages with built-in recursive capabilities. One area of application is probability and finite Markov chains.

NEWMAN'S THEOREM FOR SPHERICAL SUBMANIFOLDS. Xin-Min Zhang, Dept. of  
Mathematics and Statistics, University of South Ala., Mobile, AL 36688.

Let  $M$  be an  $n$ -dimensional submanifold of a  $m$ -dimensional Riemannian manifold  $M$ . In this paper, we introduce an isoperimetric constant  $\beta_k(M, M, \mathbb{R}^N)$  to estimate the generalized Newman number  $N_k(M)$  for  $M$  which measures the "size" of orbits when  $M$  admits a group action. For some important special manifolds such as minimal submanifolds of sphere, Kaehler submanifolds of a complex projective space, the constant  $\beta_k$  can be estimated explicitly and apply directly to the estimates of  $N_k(M)$ . As a byproduct, we also give some good estimates for upper bound of the first eigenvalue of a compact minimal submanifold of  $M$ .

## Abstracts

### NUMERICAL COMPUTATION OF THE NORMAL PROBABILITY INTEGRAL.

Larry D. Parks, Dept. of Natural Sciences, Mobile College,  
Mobile, AL 36663-0220.

DESCRIPTION: The numerical calculation of the Normal Probability Integral is frequently required in statistical analyses and probability assessments.

The method developed employs a standard computer software routine for decision making concerning the sign and magnitude of the value of the random variable that allows an economy of software and execution time on a digital computer.

The numerical algorithm is accomplished by transforming the Normal Probability Integral into a standard improper integral (error function) and then applying the standard software routine for the decision making to rewrite the transformed integral for efficient machine computation. Subsequently the numerical integration of this transformed integral is accomplished by resorting to an approximate technique developed by Cecil Hastings whose error is of the order of  $10^{-7}$ .

The algorithm has been executed in Fortran on a 32 bit machine and analysis of the results indicate that the error is between 6 and 7 decimal places.

TRACKING PARTICLES WITH HOUGH TRANSFORMATIONS. R. Kent Clark & C. Merrill Jenkins, Department of Physics, University of South Alabama, Mobile, Alabama 36688.

A continuing problem in high energy physics experiments is that of defining particle tracks from the megabytes of data obtained in today's complex detectors. These data are nothing more than (apparently) unrelated points in space. Efficiently extracting particle paths from these data is a complicated process and physicists are constantly searching for new and better ways to accomplish this task.

The Hough transformation is a technique in which lines in a Cartesian space are transformed into points in a parameter space. It is commonly used to define straight lines (and higher order curves) in digital imagery, but is virtually unknown to high energy physicists. This talk describes an application of the Hough Transformation to finding the two dimensional track parameters of particles formed in an experiment at Fermilab. While the technique underestimates the number to tracks because they overlap each other, it holds promise of being a viable algorithm when extended to the three dimensional case.

This research was partially funded by Department of Energy grant number DE-FG05-92ER40654.



## Abstracts

QUADRUPOLE EFFECTS IN THE MILLIMETER WAVE SPECTRUM OF CHLORINE NITRATE.\* Paul Helminger, Sidney H. Young, Maria Price, and John Millspaugh, Departments of Physics and Chemistry, University of South Alabama, Mobile, AL 36688.

The microwave rotational spectrum of chlorine nitrate, a molecule that is a participant in the ozone cycle in the upper atmosphere, has been investigated in the 200 GHz region. The previous measurements of the chlorine-35 and chlorine-37 species in both the ground and lowest vibrationally excited state<sup>1</sup> have been extended to include additional high-K<sub>p</sub> transitions at high J. These new transitions add significantly to the model fitting the spectrum, which in turn leads to a better prediction of unmeasured transitions. The a-type, high-K<sub>p</sub> transitions at high J are observed to be quadrupole doublets with a splitting that increases with K<sub>p</sub>. The quadrupole splittings are useful in confirming transition assignments for measured lines in the dense chlorine nitrate spectrum, and may also contribute to a refinement of the quadrupole tensor.

\*Work supported by PRF and the Research Corporation.

<sup>1</sup>R.D. Suenram and F.J. Lovas, J. Mol. Spectrosc. **105**, 351-359 (1984).

MORPHOLOGY OF POTASSIUM CHLORIDE CRYSTALS GROWN BY THE CZOCHRALSKI METHOD. A. Tan, Department of Physics, Alabama A&M University, Normal, AL 35762.\*

The shape of ionic crystals grown by the Czochralski method is strongly affected by the rotation rate. Potassium chloride crystals grown under slow rotation rates tend to have squarish cross-sections with a small cone at the bottom. The same crystals grown under rapid rotation rates tend to be circular in cross-section and wider with little or no cone at the bottom. The morphology of these crystals is discussed from the standpoint of atomic structure, nucleation and convection.

\* This study was supported by NSF under MRCE Grant-8802971. The crystals were grown by M.D.Aggarwal and W.S.Wang.

NONLINEAR OPTICAL PROPERTIES OF NICKEL CONTAINING METAL-ORGANIC MATERIALS. M. Lewis, Z. Tianyi, Dept. of Physics, D. Gale, Materials Science Dept., University of Alabama at Birmingham.

The third order nonlinear optical properties are reported for a variety of nickel containing metal-organic materials. The effect of various ligands on the nonlinearity are investigated using degenerate four wave mixing at 532nm with 20ns laser pulses from a frequency doubled Nd:YAC laser.

## Abstracts

BOLTZMANN DISTRIBUTION OF PHONONS AND LATTICE THERMAL CONDUCTIVITY. Sihon H. Crutcher and P.C. Sharma, Department of Physics, Tuskegee University, Tuskegee, AL. 36088

It has been shown that the vibrational energy of a lattice is quantized. A single linear chain consisting of identical atoms, held together by harmonic forces acting between the two adjacent atoms. In a perfect crystal, the quantized particles (phonons) possess an infinite conductivity. For a real system assuming that phonons obey Boltzmann distribution, an expression for thermal conductivity has been derived. This equation has been used to calculate theoretically thermal conductivity of semiconducting material. The theoretical values agree well with the experimental values.

This work supported by the Strategic Defense Initiative Organization's Office of Innovative Science and Technology (SDIO/TNI) through contract number N60921-91-C-0078 with the Naval Surface Warfare Center.

MORPHOLOGY OF BARIUM TITANATE CRYSTALS GROWN BY THE CZOCHRALSKI METHOD. A. Tan, Department of Physics, Alabama A&M University, Normal, AL 35762.\*

In contrast to other ionic crystals such as Sodium Chloride, the shape of Barium Titanate crystals grown by the Czochralski method is relatively unaffected by the rotation rate of the crystal. The morphology of Barium Titanate crystals is discussed from the standpoint of molecular structure and nucleation. It is shown why the (1,1,1) face is favored over the others whereby the Perovskite structure is realized. The possible arrangement of atoms on the (1,1,1) face is discussed.

\* This study was supported by NSF under MRCE Grant-8802971. The crystals were grown by W.S.Wang and M.D.Aggarwal.

STUDY OF THE PHYSICAL STATE OF WATER BY FAR-INFRARED LASER. Hantong Pang, Materials Science Program, Univ. of Ala., AL35487.

Water molecules that are within a few molecular diameters of a substrate have their rotational motions altered by bonding between the molecules and the substrate. This affects the properties of the water absorbed into the pores of a variety of materials and is a problem of fundamental importance in cell biology. One result of the bonding is that the freezing point of the water is depressed below 0 °C. We are using a far-infrared laser to study the freezing transition in detail in order to get a better description of the water-substrate bonding.

## Abstracts

A MATHEMATICAL THEORY OF ELECTROMAGNETIC COUPLING BETWEEN TWO ANTENNAS IN FREE SPACE. Larry D. Parks, Dept. of Natural Sciences, Mobile College, Mobile, AL 36663-0220.

DESCRIPTION: A mathematical theory of transmission and reception of electromagnetic waves in free space is developed by modeling two antenna as spatially separated, with known geometry, and possessing an antenna pattern of a main and a cross polarized component, and therefore constitute an electromagnetically coupled system.

The electromagnetic coupling of these energy components is accomplished by the calculation of "coupling coefficients" based on the spatial geometry of the transmit and receive antenna. The derivation of a "coupled antenna power equation" also accounts for the phasing of all signals by considering the phases as random processes possessing uniform distributions.

This mathematical model of coupling energy between antennas has been employed in computer modeling/simulation studies and has been experimentally verified.

A STATIC TWO-BODY SOLUTION IN GENERAL RELATIVITY. Joseph O. Otu and John H. Young, Dept. of Physics, Univ. of Ala. at Birmingham, Birmingham, AL 35294.

The discussion of the Weyl formulation of the static, axially symmetric Einstein field equations found in the well-known treatise by Synge (*Relativity: The General Theory*) contains the statement that a two-body solution does not exist in general relativity. We present here an explicit example of a static two-body solution. A stable two-body system should exist for the case of a spherical mass surrounded by a concentric massive ring. Utilization of prolate spheroidal coordinates is shown to cast the Weyl formulation into an exactly solvable system and to then yield a solution which can be interpreted as a sphere plus ring two-body solution.

PRESSURE DEPENDENT THERMAL CONDUCTIVITY, Jaydeep Sinha and P.C. Sharma. Department of Physics, Tuskegee University, Tuskegee, AL 36088

In this work, we have explained theoretically the pressure - and temperature - dependence of thermal conductivity of a pure specimen, whose experimental values were obtained by Alm and Backstrom. -values obtained from our calculations agree very well with those obtained by other methods. It has also been shown that the variation in Debye's temperature and the lattice parameter with the pressure is negligibly small.

This work was supported by the Strategic Defense Initiative Organization's Office of Innovative Science and Technology (SDIO/TNI through contract number DNA-001-90-C-0127 with the Defense Nuclear Agency.



## Abstracts

### INDUSTRY AND ECONOMICS

SMALL BUSINESS PREFERENCES IN RESUME' CONTENT AND FORMAT.  
Jo Mahan (Student), Gerald Crawford, and Margie S. Crocker,  
School of Business, University of North Alabama, Florence,  
AL 35632-0001

Undergraduate business students should realize that a good resume' can be a key tool in securing an interview, and, subsequently, a desirable position following graduation. However, there is little agreement on which data should be included on the resume' and which items left off.

Two hundred small businesses in Northwest Alabama were interviewed to determine their preferences on resume' content and format. This information was then compared to similar data obtained from Fortune 500 companies and to 40 professors in the University of North Alabama School of Business. The purposes were to see if small business needs were different from large businesses, and, the importance of business professors in stressing resume' construction most desirable to small businesses. The findings were as follows: (a) Small businesses placed more importance on job experience, whereas, large businesses wanted to know more detail about college performance; (b) Small businesses placed more importance on personal items on the resume' (including photo), while large businesses did not find this to be important. College professors wanted more detail on school performance and college major than was considered important by small businesses. A photo on the resume' was preferred by a margin of almost 3 to 1 over no photo by small businesses and college professors alike.

MULTIPLE REGRESSION ANALYSIS FOR THE DEMAND OF UNCOATED FREE SHEET PAPER. Paul D. Cooper, Business Division, Troy State Univ. in Montgomery, P.O. Drawer 4419, Montgomery, AL 36103-4419

Forecasting demand expectations for a product or service is a primary concern for most businesses today. This fact is especially true for capital intensive businesses like papermaking. This study provides an improvement on a multiple regression analysis for uncoated free sheet paper presently used by International Paper Company (IP). The data for each independent variable ranges from January 1983 through April 1989. An SPSS/PC+ software program was used to perform the multiple regression analysis. This program also calculated forward, backward, and stepwise selection tests with each independent variable. The original IP equation uses five independent variables with a resulting coefficient of determination,  $R^2$ , of 0.85397. This study evaluates up to twelve independent variables and eventually concludes with an  $R^2$  of 0.88175, a 3.25% improvement.

## Abstracts

AN ANALYSIS OF CONTINUING EDUCATION NEEDS OF THE SMALL BUSINESS COMMUNITY OF HUNTSVILLE, ALABAMA. Marsha D. Griffin, Department of Marketing, and James G. Alexander, Department of Economics and Finance, Alabama A&M University, Normal, AL 35762.

In the Spring of 1991, 300 small businesses representing various sectors of industry were surveyed to determine their needs for continuing education. Fifty-four businesses responded. Of the 17% who were involved in continuing education, over 55% were in the service sector and 77.8% had fewer than 25 employees. For the total sample, the subject area of marketing was designated as very important by the most respondents (42.2%), followed by basic management (33.3%), information management (31%), and accounting (27.5%). Regarding subtopics of marketing, 29.6% rated promotion as very important, followed by retailing (24.1%), industrial marketing (22.2%), and international marketing (7.4%). The percent giving a rating of very important to various subtopics of management were: sales management--37%, time management--33.3%, and stress management--24.1%. The percent giving a rating of very important to various subtopics of accounting were: budgeting and cost accounting--29.6% each, followed by financial accounting and tax accounting--25.9% each. The percent giving a very important rating to various personal computer applications were: database management--24.1%, word processing--22.2%, spreadsheets--16.7%, and desktop publishing--9.3%.

MEDIATION FOR THE SMALL BUSINESS: AN ALABAMA EXPERIENCE. Robert D. Gulbro, Department of Management, Jacksonville State University, Jacksonville, AL 36265.

One common characteristic of all small businesses is that they all lack adequate resources. Money is especially needed for investment in the business and for operating capital. It is thus absolutely necessary for a small business to maintain a positive relationship with a banker and/or a financial institution. Conflict with these creditors should be avoided if at all possible. Mediation provides a method for opening lines of communication and for resolving conflict amicably. The Farm Crisis program in Alabama is a prime example of the use of mediation to successfully solve financial problems for small agricultural businesses. Other small firms could also make use of this inexpensive alternative to litigation.

The success rate of the Farm Crisis program is compared to the success of mediation in resolving conflict in family and other personal areas. Resolving business conflicts was found to have a higher rate of success than in other reported areas.

## Abstracts

TRENDS IN INCOME DISTRIBUTION AMONG BLACK AMERICANS. James R. Bobo and Philip R. Forbus, Dep't of Economics, Univ. of South Alabama, Mobile, AL 36688.

Though many studies done in the past several years have examined trends in the relative incomes of black and white Americans, very few have focused on trends in personal income distribution within the black subpopulation. This paper uses U.S. Census Bureau, some of which is unpublished, to examine two aspects of income distribution of black Americans: first, we present data on changes from 1969 to 1990 on incomes of black Americans relative to white Americans. These data show that despite some claims to the contrary, the relative disparities throughout the range of income have remained relative constant, with slight widening of the gaps between black and white families in the past few years. Second, we show trends in personal distribution of income with the black subpopulation. This paper uses money income as the measure of income, and uses families rather than households or individuals as the unit of study. We group both black and white families by quintile, plus the top five percent of each group. Using these standards and definitions, we show that there has been a significant redistribution from bottom to top in both black and white subpopulations of U.S. families. The relative position of the lowest quintiles of both black and white families has worsened, while that of the top quintile has improved. Further, the lower on the ladder of incomes one falls, whether white or black, the worse one is likely to have fared over the period studied. We offer some tentative explanations for this phenomenon, centered on labor market behavior, macroeconomic conditions, demographic trends, and government policies.

ECONOMIC ISSUES OF REUSE IN SOFTWARE ENGINEERING. Eric N. Rahimian, Department of Economics and Finance, Alabama A&M University, Normal, AL 35762.

Development cost of a software project which utilizes other available software components is usually lower than the development cost of a totally unprecedented software project of the same size and complexity. Software technology can tremendously progress if the functionality and inner operation of any software module could be understood, generalized, classified, and identified for reuse in future software projects. In this paper, first the plausibility and justification of software reuse are described. Then, several criteria for selection of reusable software parts are discussed. Next, some economic issues of reuse as well as cost estimation of software projects which utilize reuse are examined. Finally a new approach for software project costs estimation is introduced. This approach is a hybrid of Boehm's Constructive Cost Model (COCOMO) and regression analysis which utilizes the early metrics of software size from the planned software project.



## Abstracts

GENDER DIFFERENCES IN CONFLICT MANAGEMENT STYLE REVISITED. Sylvanus S. Ogburia, Dept. of Business Administration, Alabama A&M University, Normal, AL 35762.

Studies after studies depict successful leadership in masculine terms. Work institutions reflect traditionally masculine values of competition, aggressiveness and toughness. Women may realize that their success in the workplace depends on their assuming these traditionally masculine leader-role. Thus, women may try to gain status in the workplace by expressing masculine characteristics and values. But in this process violate sex-role expectations regarding leadership and the use of power. Such women managers are usually ascribed with negative qualities, such as bitter, quarrelsome, and selfish. This description seems to confirm to the "bitch" role-type, which often has been alluded to in characterizations of high-power career women. The fear of incurring their associates' criticism and hostility by violating sex-role norms may influence female leaders to limit their power strategies to those which are congruent with sex-role expectations. As a result, we see female managers resorting to a conflict management posture that tends to use more accommodative strategies, trying to avoid conflicting situations and taking on the peacemaker - nurturing role. The high powered woman gradually regresses to more expressions of support and solidarity which eventually lead to a compromising tendency. The general stereotypic attitude towards women appear to be deeply rooted, widely shared and remarkably resistant to change. The issue is, which of these role-type control conflict management style of women: biological sex classification or gender-role classification.

NLRB AND ELECTROMATION: IMPLICATIONS FOR EMPLOYEE COMMITTEES. Edwin W. Arnold, Dept. of Management, Auburn University at Montgomery, Montgomery, AL 36117.

The Electromation case before the National Labor Relations Board (NLRB) may have a significant impact on the future of employee involvement and quality-of-worklife committees. A key issue is to determine when or how an employee committee may become a labor organization as defined in the Taft-Hartley Act. The NLRB is faced with a dilemma. If it rules for the company, it could undermine the effectiveness of the National Labor Relations Act in prohibiting employers from setting up quasi-labor organizations that could be dominated and serve as a substitute for more effective unions free from employer control. If the NLRB rules in favor of the union, topics that may be discussed in employee participation programs are likely to be limited substantially in scope, thus rendering employee committees less effective in efforts to improve productivity, quality and other issues of concern to employers and employees in the workplace.

## Abstracts

A COMPARISON OF UNIVERSITY STUDENTS' ACADEMIC SUCCESS AND PART-TIME JOB WORK HABITS. Marlon Rico and Beth Rico, University of North Alabama.

Past studies have revealed that fifty to eighty percent of university students work part-time either on or off campus. (Evangelauf)(Volkein) Students who work part-time are on the job an average of 26 to 28 hours per week. (Gannon)(Carroll)

The present study is designed to provide information on the question of how much do part-time jobs take away from student study-time. Sample data was collected from 96 full-time business students who either worked ten or more hours per week or worked zero hours at a part-time job.

Earlier research has indicated that working up to twenty hours per week has no adverse effect on grade point average. (Haller) Past indications have been that working students tend to reduce social and leisure time activities rather borrow from study time.(Wade)

Average time worked by working students in the University of North Alabama study was 25.12 hours per week. Although study-time of working students (18.6) was 4.6 hours less than nonworking students (23.2) time may have been utilized more effectively because grade point average was 2.85 compared to 2.73 for nonworking students. Working students engaged less in T.V. watching (9.1 vs 13.2), exercise (3.6 vs 4.3) and socializing (10.6 vs 23.0) for a total of 17.2 fewer hours per week than nonworking students. Credit hours taken by working students was 14.2 compared to 14.6 for nonworking students. Library research was 1.7 hours per week for each group.

THE ROLE OF PERSONALITY IN THE USE OF CONFLICT RESOLUTION STYLE.

Kerry P. Gatlin and Charles Barrett, Dept. of Management and Marketing, University of North Alabama, Florence, AL 35632.

This exploratory study investigated the relationship between the conflict resolution styles of a sample of fifty two business students as measured by the Thomas-Kilmann Conflict Mode instrument, and the communication styles typically employed by these students as measured by the Adjective Checklist (ACL) personality inventory. The Thomas-Kilmann instrument identifies five primary approaches to conflict resolution: competing (win/lose); accommodating (lose/win); compromising (win/win); collaborating (win/win); and avoiding (lose/lose). The student sample was significantly more likely to rely on a competing, accommodating, or avoiding approach than was the managerial control group.

Use of a competing style was found to be negatively related to the use of an Adult communication style (based on transactional analysis terminology). Use of an avoiding style was likewise found to be negatively related to the use of an adult communication style and positively related to the use of an adaptive child approach. The compromising style was positively related to the use of a 'free child' communication style. Training in interpersonal communication and conflict resolution is suggested by the study as is further research using discriminant and factor analysis statistical techniques.

## Abstracts

**BUSINESS ETHICS: COMPARISON AND ANALYSIS OF BUSINESS MAJOR RESPONSES.** Leon L. (Bud) Smith and Keith Absher, Dept. of Marketing and Management, Univ. of North Alabama, Florence Alabama, 35632.

Previous research suggests that the pursuit of business education leads to more tolerant attitudes toward questionable business practices than those held by students with other majors. Likewise, salespeople have shown more tolerance for such activities than students. The purpose of this research is to investigate the possibility that different business majors may develop more tolerance for questionable business activities. This was accomplished by the use of a survey developed around six scenarios in conjunction with a seven point Likert scale ranging from "very ethical" to "very unethical". The survey was administered to students majoring in: Marketing, Management, Finance, Computer Information Systems, and Accounting for a total of 242 usable responses. This research reveals a noticeable but not significant tendency for the respondents to view situations as completely ethical or completely unethical in a large percent of the responses. There were no significant differences in the responses of university business majors in this study.

**CONFLICT RESOLUTION: A BLUE AND WHITE COMPARISON.** Keith Absher, Dept. of Marketing, Univ. of North Ala., Florence AL 35632. Kerry P. Gatlin, Dept. of Management, Univ. of North Ala., Florence, AL 35632. Sherry Patterson, Dept. of Office Administration, Shoals Community College, Muscle Shoals, Alabama 35662.

The Thomas-Kilmann Conflict Mode Instrument was used to sample a group of one hundred thirteen senior management students and a group of ninety six vocational technical-students. Comparisons were made to see if significant differences existed in how each group handled conflict. Vocational-technical students were significantly more likely to use a competing and accommodating approach to conflict resolution. Management students are significantly more likely to use a compromising or avoiding approach to conflict resolution. Vocationally oriented females are significantly more likely to be competitive than female management students. Female vocational students were very similar to their male counterpart in conflict resolution. The female vocational student was much more willing to accommodate than the male management student and less willing to collaborate, compromise, or avoid conflict.



## Abstracts

### SPREADSHEETS: THEIR USE AND MISUSE.

Charles V. Briegel, T. Morris Jones, and Gerald L. Crawford,  
School of Business, University of North Alabama, Florence,  
AL 35632-0001

A survey was conducted in which data was obtained from one hundred small businesses in the Northwest Alabama area. The main area of interest was determining how computers are used in the office environment. Further, information was gathered on the use of word processing, spreadsheet, and database software packages. The principal focus of this report, however, deals with the use and misuse of spreadsheet programs.

Evidence shows that small businesses use spreadsheet programs to record accounting transactions but few use the sorting and summary capabilities that are built into these packages. Also, graphic display capabilities are not widely used to present data. None of the respondents surveyed appeared to be using the automatic recalculation of formulas (What-If) feature when building spreadsheet models. Almost two-thirds of the small businesses surveyed could effectively use a database management system, as opposed to an accounting package. In summary, it appears that many managers are wasting time developing spreadsheets for applications which can be better handled by other software packages. This is especially true in accounting applications and list manipulation areas.

### AN OVERVIEW OF THE COMMUNITY REINVESTMENT ACT OF 1977.

James Davis (MBA Student), Gerald L. Crawford, William S. Stewart, and Michael W. Butler, School of Business, University of North Alabama, Florence, AL 35632-0001

The Community Reinvestment Act of 1977 was passed to force banks and savings and loan associations "to have a continuing and affirmative obligation to meet the credit needs of the local communities in which they are chartered." The CRA was viewed as a potential solution to unserved financial needs in low income areas. Social activists in the 1960's had charged that financial institutions were guilty of cutting off credit to certain neighborhoods (and exporting money to affluent areas) thereby "redlining" an area and bringing about its deterioration.

With the passing of time and banking deregulation of the 1980's bankers and regulators began to ignore the law. In 1989, however, a tough law intended to tighten the reins again was passed...the Financial Institutions Reform, Recovery, and Enforcement Act of 1989. This law mandates public disclosure of CRA exams and extends the reach of the CRA Act of 1977.

Today, banks and savings and loans must assess community credit needs, develop a plan to meet those needs, and document the entire process. The CRA of 1977 has had a positive impact on low to moderate income areas.

## Abstracts

ACHIEVING LITERACY IN THE ALABAMA WORKPLACE. Georgia T. Buettner, Business Division, Troy State Univ. in Montgomery, P. O. Drawer 4419, Montgomery, AL 36103-4419.

Workplace illiteracy is damaging the United States' ability to compete in the international marketplace. Thirty-three percent of the American workforce is "marginally illiterate." Someone who possesses the skills equal to an education between the eighth and eleventh grade is defined as "marginally illiterate." Workplace illiteracy costs American business approximately \$20 billion annually. A workforce with basic skills deficiencies cannot be trained in advanced technologies. Workforce literacy education is taking place nationally in such companies as Motorola, Xerox, Planter's Peanuts, Polaroid and Aetna Life and Casualty Insurance Company. The Adult Education section of the Alabama Department of Education, Montgomery Workplace Skills Task Force, Russell Corporation, International Business Machines (IBM), Dana Corporation and Alabama Power Company are among the organizations contributing to workplace literacy education in the State of Alabama. The national solutions to workplace illiteracy are showing some positive results. For example, Motorola is successfully competing against the Japanese. The solutions in Alabama have begun only very recently, but show great promise. All solutions to workplace literacy, both nationally and in Alabama, must continue to grow at a rapid rate if we, as a nation, are going to meet the goals of America 2000.

Maturity Marketing. Frederick A. Viohl, University College, Troy State University, Troy, AL 36082.

Not long ago "older" people in the United States and the rest of the world were of only marginal interest to business. The "Baby Boomers" were the focus of most commercial advertising and marketing. But in recent years, all the Baby Boomers have aged and those 50 and above have grown in numbers and affluence, business has started looking at them in an entirely new way. The over-50 market is hot and business is ready to serve older consumers and their new needs. This market consists of experienced shoppers who have more free time for everything from hobbies to romance. Purchasing power in the U.S. alone for this market has been estimated at a vigorous \$800 billion a year. Business is now asking how business can help people enjoy their later years to the fullest. The corollary is, how older consumers will affect business enterprises in coming years.

## Abstracts

### SOME EFFECTS OF AUTONOMOUS WORK GROUPS ON SATISFACTION.

Dennis W. Gibson & Carlene D. Strahan, Division of Business, Troy State University in Montgomery, AL, 36103.

The purpose of this study was to determine if self-directed teams (SDT) increased worker satisfaction. With the increased demand for quality and quantity from American organizations, management is looking for improved techniques to stimulate the American workforce. A method to increase quality and quantity in American industries is the introduction of SDT in organizations. The hypotheses of the study are: (1) The greater the age of the worker, the higher the level of job satisfaction in a SDT. (2) The longer a worker is employed, the higher the level of job satisfaction. (3) The amount of training in SDT, ie: more is better, the higher the level of job satisfaction in a SDT. (4) The more group meetings held, the higher the level of job satisfaction in a SDT. The research data consists of surveys and telephone interviews of 96 members of SDT within the BellSouth organization in the Alabama and Georgia regions. Sixty-one of the ninety-six questionnaires were returned for a sixty-four percent response rate. The survey questions were adapted from the Organizational Assessment Package developed by the USAF Leadership Management and Development Center. The survey includes 20 questions concerning attitudes and opinions and 10 questions on demographic data. The SPSS/PC+ statistical program was used to tabulate the results. Chi-square values, significant at the .05 level were obtained supporting all four of the hypotheses.

### THE ALABAMA PARADOX: A STATISTICAL PHENOMENON. Macon Wilbourn, Dept. of Accounting & Finance, Auburn University at Montgomery, Montgomery, Al 36193

Assume, for hypothetical purposes, that we need more institutions of higher-learning in the state of Alabama. So let's create another. Let's call our new college the Alabama Agricultural and Professional University (A & P). We will organize A & P into three departments: agriculture, education, and business administration. Our new faculty consists of 72 professors in agriculture, 18 in education, and 13 in business. As A & P evolves, a faculty senate will be necessary for faculty input into the administrative process. Twenty representatives will be selected by department members with representation based of departmental size. But the task of determining representation may not be easy if fairness and equity is to be maintained. Such was the case in the United States Congress some 100 years ago as the state of Alabama became the victim of a statistical phenomenon which became known as the Alabama Paradox.



## Abstracts

### SCIENCE EDUCATION

#### **TEACHING AEROSPACE SCIENCE CONCEPTS TO MIDDLE SCHOOL SCIENCE STUDENTS THROUGH TEACHER-AUTHORED HYPERMEDIA COURSEWARE**

Earnest Carlisle, Joseph George, Dutchie Riggsby and Ernest Riggsby, Columbus College, Columbus, GA 31993.

Going "above and beyond" in the use of media is a strategy all teachers employ in an effort to improve the instructional environment for their students. Through the use of computers and other technological tools, we are able to construct materials that are more responsive to the individual needs of our students. Planning for the use of hyper-media in the teaching of aerospace science is a natural extension of the space age in which we live. NASA initiated the move more than 15 years ago, when in cooperation with Panasonic they endeavored to use video disks as a storage medium for all the visual materials they had available for distribution. The disk made it possible to store in a small space many hours of visual-audio materials that were in slide and motion picture format. The idea of compact storage and quick access were the keys to the interest in this approach. Today, the computer, in conjunction with CD-ROM, video-frame-grabbers, still video, and other formats, is aimed toward that same interest. We want to keep student interest, present information necessary to success in learning, and provide adequate remediation when necessary, for the diverse groups that we service in our classrooms.

ALABAMA SCHOOL OF MATHEMATICS AND SCIENCE. Allen A. Tubbs, Alabama School of Mathematics and Science, P. O. Box 161628, Mobile, AL 36616.

The Alabama School of Mathematics and Science is Alabama's public residential institution for gifted and talented eleventh and twelfth grade students with a special ability and commitment to scholarship in mathematics, science and technology. Admission is competitive via a statewide selection committee. The tuition free school offers a comprehensive liberal arts curriculum emphasizing problem-solving, critical thinking and the relationships between science and society. Interdisciplinary courses and student research are central to the program. All science courses have a laboratory component utilizing nine full laboratories. Biology, chemistry and physics each have a specific laboratory dedicated to faculty-student research. The operation of the school itself is experimental with unique academic terms and schedules, non-tenured collegiate faculty, total quality management, and funding and governance by a public-private sector partnership.

## Abstracts

### IDENTIFYING EXPERTISE IN CLASSROOM SCIENCE TEACHING.

Dennis W. Sunal, David Hedgepeth, Jeanne Suprenant, Melanie Turner Area of Curriculum and Instruction and Judith Burry Area of Behavioral Studies, College of Education, The University of Alabama, Box 870231, Tuscaloosa AL, 35487.

Schools across the country are presently attempting to solve the problem of helping students become scientifically literate by introducing a variety of new science curricula. However, teachers face special problems in these curricula (Carnegie Commission, 1991) because many are not adequately prepared to teach them, lacking either essential beliefs about science and/or an understanding of approaches of how to effectively teach science.

Recently, a great deal of effort has been devoted to identifying teachers who create meaningful learning, understanding as opposed to rote memory, of science in their students. The present study relates methods of evaluating science teacher behavior to observable characteristics of expertness in science classroom teaching. The technique we have used here is to determine if it is possible to conduct classroom observations and videotape expert components of science lessons. Using descriptive criteria developed by a nationally funded project, CREATE, to identify characteristics of expert science teaching, we have selected sequences of videotape which attempt to operationalize the descriptors of teaching. The final product is a sample of a portrait of expert elements in teaching.

HANDLING AND MANAGEMENT OF HAZARDOUS MATERIALS: A NEW ELECTIVE FOR THE CHEMISTRY CURRICULUM. Mary F. Dove, Div. of Natural Sciences, Mobile College, Mobile, AL 36663-0220.

Increased numbers of students in laboratories, decreased departmental budgets, and safety and waste disposal considerations now limit the variety of hazardous materials with which chemistry majors come in contact during their training. Any laboratory safety training they may receive is usually narrowly focused on the experiment of the day. Many graduates of chemistry programs have only a limited knowledge of the chemistry of hazardous materials and of correct handling and management practices. In order to counteract this trend in our students, most of whom are employed by the chemical process industry after graduation, an introductory 3-semester-hour course has been developed in the handling and management of hazardous materials. The course, which is in its third year, is offered as an elective for chemistry majors and as a required course for environmental technology majors, along with a companion course in environmental regulations. Topics covered in the course enable the student to achieve three objectives: (1) to identify materials which are hazardous and to evaluate the nature and extent of the hazard, (2) to be aware of pertinent regulations, and (3) to be familiar with appropriate personal protective equipment and emergency response procedures.

## Abstracts

The Importance of Estimating and Measuring for Middle School Teachers and Youngsters. Robert E. Rowsey, Department of Curriculum and Teaching, Auburn University, AL 36849.

The current standards of the National Council of Teachers of Mathematics (NCTM) for the middle school grades recommend that the topic of measurement, the use of estimating and using measurement to solve problems, is an area in mathematics that is in need of increased attention.

To have an operational understanding of a system of measurement, it is necessary for students to develop at least two basic skills in that system: (a) relationship skills and (b) application skills. Relationship skills involve students being able to convert units of measurement within that system. Application skills not only involve the comprehension necessary to apply the skill directly by measuring but also the development of an "intuitive" understanding of that application. A model was developed and tested that proved effective in teaching application skills to middle grade youngsters of differing academic abilities, genders and races. The essential ingredients for student's success were to teach them ways to make reasonable estimations and then to require them to estimate a measurement prior to actually measuring.

PHYSICAL CONSTANTS IN FRESHMAN CHEMISTRY. Larry Gerdorn, Division of Natural Science, Mobile College, Mobile, Alabama, 36663.

A comparison of  $K_{sp}$ ,  $K_a$ ,  $K_b$ ,  $E^\circ$ , and thermodynamic values from various popular freshman chemistry texts will be presented. Discrepancies will be noted for the data presented. Possible solutions to this problem will be given.

PERCEPTIONS OF UNIVERSITY STUDENTS TOWARD ENVIRONMENTAL ISSUES. Lisa Camino, SU Box 1690, Samford University, Birmingham, AL 35229. Jan Case, Dept. of Mathematics, Samford University, Birmingham, AL 35229.

A sample of twenty Samford undergraduates was given a survey consisting of sixteen questions relating to environmental issues. Approximately half of the questions dealt with the students' own behavior while the other half related to common environmental topics found in news headlines. This study examines the self perception of the students in terms of their own awareness, tests their actual knowledge, and seeks to determine if increased awareness results in participation in activities such as recycling.



## Abstracts

CRITICAL MASS: SCIENTIFIC LITERACY. Susie H. Shepard, Department of Secondary Education, University of South Alabama, Mobile, Alabama 36688.

In the literature, studies abound which confirm the lack of scientific understanding in the simplest form by the total American populace. The average college graduate is scientifically illiterate. Studies have estimated that fewer than seven (7) percent of American adults can be classified as scientifically literate. One can only conclude that the problem has reached "critical mass" proportions. The problem is not defining scientific literacy. The ominous task is to recognize that an appalling situation exists and to search for solutions. This paper addresses the current national status of scientific literacy, along with some background on programs currently in place at the University of South Alabama. Related data from other institutions of higher education are discussed to give a more comprehensive picture of what can be accomplished through cooperative interaction of all colleges and divisions on an individual university campus. The suggestions are focused on degree programs for the non-traditional student, non-science major, and undeclared major.

SUPERMARKET SCIENCE: A HANDS-ON WORKSHOP FOR ELEMENTARY TEACHERS. Nancy C. McDonald, Dept. of Chemistry, Athens State College, Athens, AL. 35611

A set of activities in the areas of Life Science, Physical Science, Earth Science, and the Scientific Method were developed by the District Directors of Alabama Science Teachers Association. The objective was to provide simple and inexpensive hands-on activities for elementary students in grades 4-6, train the teachers, and provide materials for implementation. The District X workshop is reported here. Funding for materials was provided by a \$500.00 Mini-Grant from the Alabama Academy of Science.

STUDYING HANDBELLS IN THE UNDERGRADUATE PHYSICS LABORATORY. Randy Russell and David Martin, Department of Physical Sciences, Auburn University at Montgomery, Montgomery, Alabama 36117-3596

Study of vibrating objects in the undergraduate physics laboratory has traditionally been limited to looking at the individual harmonics of vibrating strings. With the advent of low-cost computer data acquisition hardware, and accompanying FFT software, however, the modes of vibration for almost any musical instrument can be determined from its sound while all of its modes are excited at the same time. The software and hardware for this process are designed for the undergraduate physics laboratory. This process has been used by the authors to study the modes of vibration for a ringing handbell and how those modes produce a non-uniform sound field.

## Abstracts

### SOCIAL SCIENCES

THE THEORY OF CENTRISMS. Gene A. Harris and Glen D. Baskett, Department of Psychology, Tuskegee University, Tuskegee, AL 36088.

The concept of a tripartite personality is an element of psychological study which has existed for hundreds of years. From the time of the ancient Greeks to the time of Freud, the overall conception of this personality has evolved in new and subtle ways. While the analysis of the tripartite theory and its development constitute a major part of this paper, it is only the foundation upon which current and future research interests are based. Although it is accepted that each part of the Freudian personality (id, ego, superego) is a part of an individual's personality, it is additionally believed that each of the three aforementioned parts are separate and distinct stages of personality development. The current focus of research pertaining to this issue attempts to validate the existence of three styles of personality development derived from the Freudian psychoanalytic personality. These three stages of personality development are as follows: (1) Idcentric, (2) Egocentric, and (3) Superegocentric. Thus, it is believed that individuals will display patterns of behavior representative of one or another of these stages depending upon their overall level of personality development. Conclusively, it is felt that the aforementioned stages of personality development can be verified through the creation of a personality inventory designed to measure behavioral differences between and among human beings.

THE DAUPHINE ISLAND SEA LAB AND M.E.S.C.: THE FIRST TWENTY YEARS. Peter F. Barty, Dept. of History & Pol. Science, Univ. of Nth. Ala., Florence, AL 35632.

One of the best kept secrets on the Gulf Coast of Alabama is the existence of and the work done by the Marine Environmental Sciences Consortium located at the Dauphine Island Sea Lab. Established in 1972 by agreement of eighteen Alabama colleges and universities, the Consortium has survived hurricanes, fiscal problems, personnel problems, neglect by the college and university presidents and neglect by the state legislature. It survives today due to the dedication of the faculty and staff of the facility along with the resolute efforts of several individuals who are determined to see the Consortium's success. It has gained a world-wide reputation in the area of marine biology and estuarine studies, while its graduates both at the doctoral and the masters level continue the efforts to pierce the mysteries of the deep and to preserve the environment of our wetlands.

## Abstracts

The Computer Hassles Scale: preliminary psychometric properties.

Richard A. Hudiburg, Bruce Sides, & T. Morris Jones, University of North Alabama, Florence, AL.

The development of the Computer Hassles Scale (CHS) was the focus of this study. The Computer Hassles Scale is a 37-item scale derived from the first two rotated principal factors of the pervious developed Computer Technology Hassles Scale (CTHS). The Computer Hassles Scale's items dealt with actual computer use rather than computer technology in general. Reliability of the CHS and correlates of the CHS to other measures were investigated.

A questionnaire was constructed that included demographic information, the Perceived Stress Scale (PSS), the Computer Attitude Scale (CAS), the Computer Hassles Scale (CHS), and the somatic complaint items of the Hopkins Symptom Checklist (HSCL). The questionnaire was initially administered (Time1) to a sample of students ( $N = 223$ ). A shorter questionnaire (demographic questions, CHS, HSCL) was given (Time 2) to a subsample ( $N = 108$ ) who completed the first administration.

Reliability analysis indicated that the CHS severity score was moderately stable ( $r = .60$ ). Correlation analyses indicated that the CHS severity score was not correlated with the other scales (PSS, CAS, HSCL) used in the study. The only significant correlation ( $r = .27$ ) was between the CHS and self-rated computer knowledge for Time 2. For those students enrolled in a computer course, the CHS severity score was significantly correlated ( $r = -.32$ ) with the course grade only for the Time 1 administration.

The evidence suggests that the Computer Hassles Scale behaves differently, based on correlates, than the Computer Technology Hassles Scale. The CHS is measuring something other than computer-related stress.

BEYOND BLACK POLITICAL EMPOWERMENT: THE QUEST FOR BLACK PARITY TOWARDS THE YEAR 2000. Lawrence J. Hanks, Department of Political Science, Tuskegee University, Tuskegee, AL 36088

From the codification of slavery to the passage of the 1965 Voting Rights Act, the African American collective believed that black political empowerment was the key to black political, social, and economic parity. With the gaining of access to the ballot with the 1965 Voting Rights Act, it was widely believed that the socioeconomic status of the African American collective would rise due to the passage of positive public policy by black politicians or other politicians who were sensitive to the power and the plight of African Americans. After more than a quarter century of black political power, the black community still has not gained political, economic, or social parity.

This paper examines the current efforts of the African American community to move beyond the strategy of black political empowerment. It critiques the theory of black political empowerment and examines strategies which are primarily economic and social. These strategies include black economic development, the strengthening of black educational and cultural institutions, and an emphasis on personal development. This paper argues that although the African American community will continue to develop politically, there will be more of an emphasis on social and economic strategies as the year 2000 approaches.



## Abstracts

CORRELATES OF ATTITUDES TOWARD AIDS IN ALABAMA COLLEGE STUDENTS: RACE, SEX, SEX EDUCATION, RELIGION, AND SELF-ESTEEM. Larry W. Bates and Charles E. Joubert, Department of Psychology, University of North Alabama, Florence, AL 35632.

This study addressed the relations between self-esteem, sex, sex education, race, church attendance, and attitudes toward AIDS precautions in Alabama university students. Attitudes toward AIDS precautions were measured as the identity formation statuses of diffusion, foreclosure, moratorium, and achievement. Sex education was found to be important in assisting adolescents to form more mature attitudes, beliefs, and values which lead to appropriate responses to AIDS precautions. Adolescents receiving their sex education from parents were predictive of higher self-esteem and more frequent church attendance. Approximately two-thirds of the respondents intend to use condoms in their next sexual encounter. Those who intend to use condoms were likely to have identity achievement status while those who did not intend to use condoms were likely to be identified with identity moratorium status. Neither sex, race, nor denominational affiliation was found to be a predictor of attitudes toward AIDS precautions, self-esteem, or intentions to use condoms in the future.

STATISTICAL ANALYSIS OF SAT SCORES 1966-89. Judd Fleming, Jason Trummell, Jeff Archer, students at Samford University, P. O. Box 1067, Mary H. Hudson, Assistant Professor Mathematics, Samford University, 800 Lakeshore Drive, Birmingham, Alabama 35229.

The SAT Comparative Data team project is a statistical research project investigating nationwide SAT scores over the past 20+ years. The study includes: (1) descriptive statistics of the scores in different ways such as male vs. female, ethnic background, type high school, and type of major; (2) a two-sample t test comparison between SAT scores in the Southeast and Northeast; (3) regression analysis to obtain a prediction model of future scores. The results of this data show how scores have varied over the past 20+ years, and in some cases the conclusions are quite alarming.

## Abstracts

### HEALTH SCIENCES

HIV: PSYCHOSOCIAL RESPONSES. Susan W. Gaskins, Capstone College of Nursing, The University of Alabama, Tuscaloosa, AL 35487-0358

Human Immunodeficiency Virus (HIV) Disease/Acquired Immune Deficiency Syndrome (AIDS) has become a major medical and social problem. While there has been much research on biological aspects of HIV, little systematic investigation has been conducted on the many and varied psychosocial responses to HIV. The purpose of this study was to identify and describe psychosocial responses to being infected with HIV as reported by HIV infected persons.

Ten adults, infected with HIV for 4 months to 5 years, comprised the sample. During an interview, participants were audiotaped as they described personal feelings and experiences as an HIV infected individual.

The interviews were analyzed using grounded theory methodologies. The core category which emerged from the data was Fighting to Survive with HIV Infection. Supporting concepts were Taking Care and Adjusting to Changes in One's Autobiography. Within the supporting concept to Taking Care were processes of Everyday Work and Illness Work which enabled the subjects to have some control over their lives and the disease and gave them hope. The processes involved in Adjusting to Changes in One's Autobiography were not knowing, accepting homosexuality, experiencing changing feelings, protecting confidentiality, dealing with the medical profession, dealing with multiple losses, and living with terminal illness.

Two stages of responses were clear from the data. The first stage was in response to the diagnosis in which the subjects made decisions about whether to commit suicide, who to tell about their diagnosis, and changes that were needed in their lifestyles. The second stage, was in response to continuing to live with HIV infection. In this stage, the subjects made about how to fight to survive with the disease.

Implications from the study include the importance of nurses and other health professionals being aware of and supporting HIV infected individuals in their fight to survive with the disease. Further research is recommended on how HIV infected individuals make decisions about fighting to survive.

AIDS-RELATED KNOWLEDGE AND ATTITUDES OF ALABAMA LICENSED DAY CARE ADMINISTRATORS AND TEACHERS. Deborah Poteet-Johnson, Peggy O. Jessee, and M. Christine Nagy, The University of Alabama School of Medicine--Tuscaloosa Program 35401.

The subject of AIDS is a critical topic in family-related health issues. The number of HIV-infected preschool children is increasing and, due to medical advances in treatment, these children are living longer. Federally-funded day care programs will likely be called upon to provide developmental and educational opportunities for AIDS-infected children from low socio-economic groups. To address these issues a pilot project was developed to evaluate AIDS knowledge and attitudes of administrators and teachers of community-based licensed day care centers in Alabama. Results indicated that there were gaps in pertinent areas of knowledge concerning non-proven methods of AIDS transmission. Furthermore, although three-quarters of the providers had access to protective gloves, more than one-third did not use gloves on a regular basis when exposed to the children's bodily fluids or excrement.

## Abstracts

SELF-CONCEPT AND SELF-CARE PRACTICES OF HEALTHY ADOLESCENTS. Alberta K. McCaleb. Department of School of Nursing, UAB, Bham, 35294-1210.

The purpose of this descriptive study were to: (a) ascertain if there is a relationship between self-concept and self-care practices of healthy adolescents; and (b) ascertain if there is a relationship between self-care practices and the covariates of self-concept and the conditioning factors of age, gender, developmental status, family and sociocultural characteristics, and health state of adolescents. Orem's Self-Care Model and developmental theory provided the framework for this investigation. The convenience sample consisted of 160 males and females, 15 to 16 years of age, enrolled in tenth grade English class in two school systems within a rural county in a southeastern state. The typical subject was Caucasian (89%), lived with both parents (67%), and had two or less siblings (70%). The findings from this investigation revealed that adolescents are engaging in self-care practices to meet general and universal self-care. Self-care practice scores (Denyes Self-Care Practice Instrument) were lowest in the area of nutrition and highest with regard to safety. The adolescents in this sample had average or slightly above average self-concepts (Piers-Harris Self-Concept Scale). The statistical hypothesis that there is no relationship between self-concept and self-care practices was rejected ( $r=.41$ ,  $p<.001$ ). A stepwise, multiple regression analysis revealed four significant predictors of self-care practices ( $R^2=.26$ ,  $F=11.9$ ,  $p<.001$ ). Significant predictors included: self-concept, church attendance, race, and participation in the paid lunch program. The single best predictor of self-care practices was self-concept ( $R^2=.17$ ,  $F=28.8$ ,  $p<.0001$ ). Findings from this study supported Orem's theoretical proposition that self-concept influences self-care practices. Recommendations included replication of the study with a more heterogeneous randomized sample.

RESTORING MODESTY IN THE POSTPARTUM WOMAN. Ellen Buckner, Sarah Johnston, Sharon Hall, Louise Yielding, Donna Mason, University of Alabama School of Nursing, UAB and St. Vincents Hospital, Bham, AL

With the physiological changes of pregnancy and birth the woman experiences major developmental change. Perinatal care, though standard, necessarily involves frequent assessments and physical examinations which may be perceived as embarrassing or invasive. Changes in body image in pregnancy includes alterations in body boundary, perception and appearance. The postpartum period offers an opportunity for the woman to restore her sense of modesty and re-establish body boundary and self-care. This restoration is necessary for her to complete developmental transitions. Nursing measures which can facilitate this recovery include: a) providing privacy b) limit public conversation c) obtaining permission and d) encouraging self care. For mothers at risk of difficulty in restoring modesty and intact body image interventions may include more in-depth assessments and education.



## Abstracts

SELF-CONCEPT CHANGES DURING PREGNANCY. Sharon L. Hall, RN, PhD, School of Nursing, Univ. of Ala., UAB Station, Birmingham, AL 35294-1210.

A triangulated design utilizing both qualitative and quantitative techniques was used in a purposive sample of married primiparas ( $n=32$ ). Instruments used in the quantitative phase of the study were the Tennessee Self-Concept Scale (TSCS) and the Prenatal Self-Evaluation Questionnaire II, measuring self-concept at three points during the pregnancy. Additionally, a semi-structured interview was used with a subsample of twelve subjects in their third trimester. Quantitative and qualitative data revealed no change in core self-concept between trimesters; however, statistically significant changes were noted in the subscales of both instruments. Analysis of the TSCS indicated change ( $F=4.48$ ,  $df=2,62$ ,  $p<.05$ ) in the Social Self subscale. Analysis of the Prenatal Self-Evaluation Questionnaire II indicated change in the following subscales: Acceptance of Pregnancy ( $F=3.9$ ,  $df=2,62$ ,  $p<.05$ ), identification of the Motherhood Role ( $F=3.59$ ,  $df=2,62$ ,  $p<.05$ ), Fear of Pain and Loss of Control ( $F=7.68$ ,  $df=2,62$ ,  $p<.001$ ), and Preparation for Labor ( $F=38.9$ ,  $df=2,62$ ,  $p<.0001$ ). Data obtained from these interviews partially corroborated the findings. The predominant discrepancy between data obtained via the instruments and the interviews appeared to be the many physical changes noted by the informants but not detected by the TSCS. These discrepancies can be explained by the fact that the TSCS lack specificity for the experience of pregnancy, especially in the physical and moral-ethical subscales. A second possible explanation for the discrepancy is that the women who participated in this study were experiencing a healthy pregnancy, without complications or trauma. Therefore, a normal pregnancy may not be a situation intense enough to cause change in the overall self.

PET ATTACHMENT AND OTHER ENVIRONMENTAL FACTORS: CAN THEY PREDICT FAMILY FUNCTIONING? Ruth P. Cox, Sch. of Nursing, Univ. of Ala. at Birmingham, Birmingham, AL. 35294.

The purpose of this study was to investigate whether family functioning could be predicted from pet attachment and other elements in the environment. The Ecosystems Approach and General Systems Theory provided the theoretical orientation for this research. A survey research design was utilized in which marriage and family therapists in six southeastern states distributed questionnaires to their clients and family members. Results indicated that 24% of the variance in family adaptability could be significantly accounted for with these variables. The role of these findings for marriage and family therapists, health care professionals, and family life educators were discussed.

## Abstracts

SELF-ESTEEM, SENSE OF MASTERY, AND ADEQUACY OF PRENATAL CARE. Margaret R. Edwards, Northeast Louisiana University, Monroe, LA 71209-0460.

Adequate prenatal care has been shown to decrease the alarmingly high incidence of low birth weight and infant mortality in the United States. The low-income population, however, which is at highest risk for low birth weight and infant mortality, uses prenatal care services less than other population groups. Psychological factors, including self-esteem and sense of mastery or control over one's life, may influence the decision to obtain prenatal care. Low-income populations are thought to have particular problems with self-esteem and sense of mastery. Therefore, the purpose of this study was to determine whether there are differences in self-esteem and sense of mastery between low-income pregnant women who obtain adequate prenatal care and low-income pregnant women who do not obtain adequate prenatal care. In health department maternity clinics in Louisiana, 102 low-income adult women in the third trimester of pregnancy completed the Rosenberg Self-Esteem Scale and the Pearlin Sense of Mastery Scale. Prenatal care adequacy was evaluated using the Kessner Index. Both self-esteem and sense of mastery were found to be significantly higher among low-income pregnant women who obtained adequate prenatal care than among their counterparts who did not obtain adequate prenatal care. Analysis of covariance showed that education and level of poverty also influenced prenatal care adequacy, but both self-esteem and sense of mastery exerted a significant main effect, independent of the influence of education or level of poverty. The results of this investigation may direct nurses to promote self-esteem and sense of mastery in low-income women of childbearing age. This may represent one step in the fight against inadequate prenatal care and infant mortality in the United States.

MEDICAL ASPECTS OF THE PERSIAN GULF WAR. Robert E. Pieroni, M.D., Col, USAR, Dept. of Internal Medicine and Family Practice, Univ. of Ala, University, AL 35487.

As in virtually all military conflicts, medical illnesses during the Gulf War resulted in much greater morbidity than enemy action. I shall describe some of our experiences at the busiest coalition hospital in the entire Gulf region. During Desert Storm/Shield and its aftermath we treated over 40,000 patients of many nationalities. We were presented with a wide variety of diseases, many considered "exotic" or "esoteric" by Western standards. I shall discuss types of diseases encountered, caliber of the medical facilities and personnel available, state of medical preparedness, and overall medical management of the coalition soldiers, prisoners of war, and civilians. Preparations for potential biological and chemical warfare will be discussed as will lessons learned, and proposed methods to decrease medical and surgical casualties and ensure optimal care of patients should future conflicts arise.

## Abstracts

PREGNANCY: PERCEPTIONS OF BLACK ADOLESCENTS. Margaret G. Tennyson, Dept. of Nursing, LSU Medical Center, New Orleans, LA 70112.

The purpose of this study was to discover the perceptions of black adolescents about the phenomena in their lives at the time of conception. Eleven pregnant, black adolescents comprised the sample of this qualitative inquiry. The subjects completed three interview: (a) at 37 to 39 weeks of pregnancy, (b) 1 to 3 days postpartum, and (c) approximately 3 weeks following delivery. Data were analyzed according to methods described by Patton. Three categories of themes which emerged from the interviews were unthinking, blaming, and mistake. In the category of unthinking, the adolescent perceives that they were not thinking of pregnancy at the time of intercourse. For them, pregnancy "just happened." With blaming, the adolescent will blame external forces for their pregnancy, such as their partner. In the category of mistake, the adolescent claims their pregnancy was a mistake. Therefore, the major theme that evolved from the data is the inevitability that pregnancy would occur. Identification of stressors from Neuman's Systems Model was not found to be useful. The following recommendations are offered: (a) replicate this study as close as possible with a black female interviewer, (b) use grounded theory methodology to develop a theoretical basis for the meaning of pregnancy for black adolescents, (c) promote individual counseling for disseminating sex education knowledge to promote prevention at an individual level, (d) because the findings suggest the inevitability of pregnancy, there should be an increased focus on providing health care at all levels of prevention, with a particular interest on healthy mothers and babies. The investigator would like to acknowledge Dr. Janice Gay, Committee Chairperson, & Committee Members for their encouragement and support throughout this study.

DETERMINATION OF CRITICAL VALUES FOR TRIPLE TEST SCREENING FOR DOWN SYNDROME. Da-Chang Chu, Larry Boots, and Richard Davis, Department of OB/GYN, The University of Alabama at Birmingham, Birmingham, AL.

Human chorionic gonadotropin (HCG), maternal serum alpha-feto protein (MSAFP), and unconjugated estriol concentrations were measured in frozen serum samples collected from 1347 pregnant women participating in a prenatal MSAFP screening program. The patient group was composed of 983 white and 364 black patients ranging from 14-21 weeks of gestation. The purpose of this study was to obtain reference data for development of a prenatal screening program to detect Down syndrome-affected pregnancies. AFP values for the study group were  $27.88 \pm 14.34$ ,  $41.24 \pm 85.72$ ,  $45.87 \pm 91.43$ ,  $45.85 \pm 21.03$ ,  $51.96 \pm 25.4$ ,  $62.55 \pm 27.62$ ,  $74.93 \pm 36.41$ ,  $82.98 \pm 37.87$  ng/ml for gestational weeks 14-21 respectively. HCG values for the study group were  $66280 \pm 46785$ ,  $59080 \pm 40400$ ,  $48975 \pm 35325$ ,  $43950 \pm 40205$ ,  $37295 \pm 30330$ ,  $31890 \pm 25105$ ,  $31565 \pm 28905$ ,  $22205 \pm 19625$  mIU/ml for gestational weeks 14-21, respectively. The unconjugated estriol values obtained were  $0.58 \pm 0.39$ ,  $0.78 \pm 0.49$ ,  $1.01 \pm 0.7$ ,  $1.34 \pm 0.82$ ,  $1.52 \pm 0.71$ ,  $1.82 \pm 0.9$ ,  $2.12 \pm 1.07$ ,  $2.05 \pm 0.9$  ng/ml for gestational weeks 14-21, respectively. These data will be used to detect those pregnancies at highest risk for Down syndrome.



## Abstracts

PATIENT-CONTROLLED VS. NURSE-ADMINISTERED ANALGESIA-THE EFFECT ON PAIN INTENSITY AND DISRUPTION IN SELF-CARE ACTIVITIES AMONG TOTAL ABDOMINAL HYSTERECTOMY PATIENTS. DeLaine B. Pate, Golden Triangle Regional Medical Center, Columbus, MS. 39701.

The purpose of this study was to ascertain if there is a difference in pain intensity and disruption in self-care activities in surgery patients who control their own postoperative analgesia vs. those patients who receive nurse administered intramuscular analgesia. The gate-control theory of pain and Orem's self-care theory of nursing were utilized for the theoretical framework. The sample consisted of 21 postoperative total abdominal hysterectomy patients between the ages of 29 and 53 years. Beginning on the day of surgery, the patients completed a visual analogue scale measuring pain intensity every 8 hours and a self-care questionnaire measuring disruption in activities every 24 hours for a 72 hour period. Repeated measures ANOVAs revealed no significant interaction between group and time of measurement for pain intensity or self-care scores. For the three pain intensity ratings within each 24-hour period, results revealed no significant differences across time. However, the main effect across the three 24-hour time measurements was significant, with the trend to progressively decrease over the three days. Results revealed no statistical differences between group scores for pain intensity for any 24-hour period. For self-care scores, the main effect across time was significant, with the trend to increase participation in self-care over the three days. There was no significant difference between the groups. It was recommended that research be conducted on how previous experience with postop pain control, previous knowledge of various methods of pain control, &/or desire for control affect pain intensity and self-care activities in postop patients. Research should be conducted on how pain affects other self-care requisites.

NURSING ASSESSMENT OF THE EFFECTS OF SOCIOECONOMIC STATUS ON HEALTH PROMOTION PRACTICES, ATTITUDES, AND KNOWLEDGE ABOUT CANCER IN AFRICAN AMERICANS. Linda Thomas, UAB School of Nursing, Birmingham, AL 35294.

A study on behavioral practices, attitudes and knowledge about cancer for African Americans of different socioeconomic status was undertaken, using the Health Belief Model as the conceptual framework. Results reinforced findings from previous studies that suggested the disproportionately higher cancer statistics for incidence and mortality rates and poorer survival rates are strongly linked to income and educational levels. Results indicated participants with less education were more negative about the health care providers and more pessimistic about cancer and cancer prevention ( $p .0009 < .05$ ). Analysis revealed the higher the income the more knowledgeable individuals were about cancer risk ( $p .0441 < .05$ ). Health promotion behavior practices significantly differed based on income level ( $p .0112 < .05$ ). The higher the income the more likely the individual was to practice health promoting behaviors such as having screening tests, eating proper foods and quit smoking. A regression plot revealed a slightly positive correlation between cancer knowledge and behavior practices ( $r .19806$ ) = .039.

## Abstracts

PREGNANCY WANTEDNESS, ATTITUDE TOWARD PREGNANCY AND DRUG USE AT EARLY AND LATE PREGNANCY. Victoria L. Poole, School of Nursing, Univ. of Alabama at Birmingham, Birmingham, AL 35294-1210.

Utilizing secondary analysis of previously collected data from the Intrauterine Growth Project (IGP), a descriptive correlational design was used to examine pregnancy wantedness, attitude toward pregnancy, and drug use behaviors of 1,213 pregnant women at early pregnancy and late pregnancy. Neuman's Systems Model was used in methodology development and interpretation of the findings. Descriptive statistics and Chi-square were utilized to analyze the data. Pregnancy wantedness at early and late pregnancy was significantly related. Attitude toward pregnancy at early and late pregnancy was significantly related. Drug use at early and late pregnancy was related. A significant relationship was found between pregnancy wantedness and drug use at early pregnancy but not at late pregnancy. No significant relationships were found between attitude toward pregnancy and drug use during early and late pregnancy. Early identification of pregnancy unwantedness and negative maternal attitude affords the nurse the opportunity to implement secondary and tertiary interventions to reduce the risk of child neglect or abuse. The finding that women reduced use of alcohol and street drugs but continued to use tobacco during pregnancy points to the need for nurses to develop and implement programs that promote healthy lifestyle behaviors before the women becomes pregnant. To reduce unwanted pregnancies, nurses must become patient advocates and be politically active in forming health policies to ensure that access to family planning is available to assist women who want and do not want to become pregnant.

SECOND-TRIMESTER HORMONE LEVELS IN RELATION TO INFANT SEX AND BIRTH WEIGHT. Nancy Rich, Larry Boots, and Richard Davis, Department of OB/GYN, The University of Alabama at Birmingham, Birmingham, AL.

Maternal serum levels of alphafetoprotein (AFP), human placental lactogen (HPL), pregnancy-specific protein (SP<sub>1</sub>), total estriol (E<sub>3</sub>), free estriol (FE<sub>3</sub>) and human chorionic gonadotropin (HCG) were measured in 316 women ranging from 14 to 20 weeks of gestation. All pregnancies were considered to be medically normal. There were 158 male and 158 female infants delivered as a result of these pregnancies. Means  $\pm$  1SD were calculated for each hormone at each week of gestation for pregnancies associated with male or female fetuses. AFP, HPL, SP<sub>1</sub>, E<sub>3</sub> and FE<sub>3</sub> levels all increased from 14 to 20 weeks of pregnancy as follows: 34.0 - 74.1 ng/ml, 10.5 - 21.2 ug/ml x 10, 21.9 - 39.8 ug/ml, 6.7 - 21.8 ng/ml x 10, 5.0 - 14.5 ng/ml x 10, respectively. HCG levels reached peak levels of 51106 mIU/ml and declined to 23,845 mIU/ml at 20 weeks. There were no significant differences in any of these hormone levels regardless of infant sex. Correlations were also calculated for infant weight at birth in relation to hormone levels during the second trimester. There were no significant trends observed. In conclusion, neither the sex of the infant nor infant weight at birth appeared to be related to any of these hormone levels during the second trimester.

## Abstracts

DEVELOPMENT OF ANDROSTENEDIOL AND 11-HYDROXY-ANDROSTENEDIONE ASSAYS FOR THE STUDY OF HYPERANDROGENIC SYNDROMES. Larry Boots, Beth Boots, H. Downing Potter and Ricardo Azziz, Department of OB/GYN, The University of Alabama at Birmingham, Birmingham, AL.

Hirsutism in women is generally caused by excessive production of male hormones. These hormonal imbalances can generally be treated if the underlying problem can be determined. Depending on the source of male hormones, treatment will vary but can make use of a variety of drugs including spironolactone, birth control pills, long-acting gonadotropin-releasing hormone analogues, prednisone or dexamethasone. While several laboratory assays are already well-established for clinical study of hyperandrogenic syndromes, the underlying cause of hormonal imbalance may still remain elusive. Some patients synthesize androgens which are relatively uncommon. It was the purpose of this study to develop radioimmunoassays for two such androgens, androstenediol (Adiol) and 11-hydroxy-androstenedione (11-Adione). Both hormones were ether extracted from 0.5 ml serum. The organic layer was removed, taken to dryness, resuspended in chloroform: heptane: ethanol(200:200:1). The antibody to be used in the Adiol assay was known to crossreact with testosterone, while the antibody to be used for H-Adione cross-reacted with both testosterone and androstenedione. Therefore, separation by Sephadex LH-20 column (17x1 cm) chromatography was required. In this solvent system, testosterone elutes at 5-7 ml, Adione at 6.5 - 8.5 ml and androstenediol at 19-21 ml. The 19-21 ml eluate was collected, taken to dryness and assayed. The 5-8.5 ml fraction was transferred to a second column in methylene chloride: methanol (95:5). In this system, testosterone eluted at 4-6 ml while Adione eluted at 8-10 ml and can subsequently be assayed. These assays are currently being validated and normal ranges in patients are being established.

DIETARY AMINO ACID INTAKES IN MALE BODYBUILDERS: A COMPARISON OF DIETARY SOURCES VERSUS SUPPLEMENTS. Robert E. Keith, Michael H. Stone, Ralph E. Carson and Robert G. Lefavi. Dept. of Nutrition & Food Science, Auburn Univ., AL 36849.

Fifteen male bodybuilders (19-41 yr) participated in a study to determine normal dietary intakes of the essential amino acids and arginine. Dietary intakes were obtained from 3-day food records. Intakes were compared to established human requirements and to the level of amino acid supplements consumed for ergogenic purposes. Results indicated subjects consumed a mean of 4346 kcal and 257 g protein/day. Essential dietary amino acid intakes were as follows (mean, range): leucine, 16.3 g/day (7.3-38.6); isoleucine, 10.4 (4.6-24.8); valine, 11.3 (5.2-26.1); total aromatic, 15.7 (7.6-38.0); total sulfur, 7.2 (3.6-17.6); tryptophan, 2.4 (1.1-5.7); threonine, 8.4 (3.7-19.8); lysine, 14.8 (5.8-36.0). Essential amino acid intakes from diet alone were 8-11 times greater than established human requirements. Mean arginine intake was 14.1 g/day (6.8-27.5). Essential amino acid and arginine intakes from diet alone were similar to levels administered for ergogenic purposes as cited in the scientific literature. Amino acid supplements used by the subjects, when consumed according to manufacturer recommendations, provided 2.1- 10.6 % of the same amino acid as provided in the subjects' diets. It would seem doubtful that amino acid supplementation would provide any significant additional benefit above that of diet alone in the present group of subjects.

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## Abstracts

OCCURRENCE AND CAREGIVERS' KNOWLEDGE OF CARDIOVASCULAR RISK FACTORS IN YOUNG CHILDREN. Joan Carlisle, Nancy Corser, Vera Cull, Wendy DiMicco, Lois Luther, Alberta McCaleb, Janet Robuck, University of Alabama School of Nursing, and Kathleen Powell, University Hospital, UAB, Birmingham, AL 35294.

Research supports that identification of cardiovascular (CV) risk factors during childhood may predict heart disease in later life. Family history, dietary patterns, cholesterol screening, and physiologic and anthropometric measurements are useful in the detection of children at risk. The purposes of this study were to identify CV risk factors in 2- and 3-year-old subjects and to identify caregivers' knowledge of those factors. Subjects had an average of 79% of recommended calories for age with 33% of calories from fat. Blood pressure was above normal for only two children. Forty percent of subjects had abnormal cholesterol patterns. Total cholesterol (TC) over 170mg/dL was found in 26% of subjects with 21% having HDL levels less than 29mg/dL. Two subjects demonstrated a pattern of high TC and low HDL. Family history was positive for 10 children and negative for 11 who had high TC and/or low HDL. High risk children might have gone undetected if family history had been the only indicator for screening or if HDL had not been included. Caregivers scored an average of 72% on the knowledge test. Frequently recognized factors were smoking, obesity, hypertension, family history, high fat diet, high TC, and stress.

Acknowledgement: UAB School of Nursing, PhoTest Diagnostics, Nu Chapter, Sigma Theta Tau

ALABAMA PHYSICIANS' ATTITUDES TOWARDS A NATIONAL HEALTH PROGRAM. Amy Alderman and Barbara Lester, Birmingham-Southern College, Birmingham, AL 35254. Max Michael, Cooper Green Hospital, Birmingham, AL 35294.

Physicians in Alabama were surveyed to determine their opinions on a national health program and their perceptions of the effects of such a program on physician's autonomy, patient care, health care costs, and physician's income. A questionnaire was sent to a random sample of 400 Alabama physicians; the response rate was 71%. The methods of analysis were factorial analysis, crosstabs, and chi square. The geographical location and age of the physicians were the most important predictors. The urban or rural location of the physicians appears to affect their attitudes toward controlling health care costs and their beliefs about an upcoming crisis in the health care system. The age of the physicians is significant in their concerns about physicians' incomes. Controlling for gender had no effect on the relationship. Furthermore, Alabama physicians appear more conservative in their views of a national health program compared to national statistics.

## Abstracts

PERCEIVED STRESSORS AND COPING STRATEGIES OF PARENTS WITH DEVELOPMENTALLY DISABLED CHILDREN. Doris J. Heaman, The University of Alabama in Huntsville College of Nursing

The purposes of this study were to describe perceived stressors and coping strategies of parents with developmentally disabled children and to ascertain if there were gender differences in perception of stressors and coping. The sample consisted of 203 parents of disabled children. Descriptive statistics and stepwise discrimination analysis were used to examine stressors and coping strategies and to ascertain gender differences. The stressor reported by the largest number of mothers and fathers was concern about the child's future. There were significant differences between mothers and fathers in perception of stressors which were concerns about agencies to provide care, the child's health, sexual relations with spouse or partner, and having enough insurance to meet expenses of child care. The coping strategies reported by the largest number of mothers were categorized as seeking social support, problem-solving, and positive-reappraisal. The coping strategies reported by the largest number of fathers were categorized as self-control and problem solving. There were significant differences between mothers and fathers in coping strategies which were categorized as escape-avoidance, positive reappraisal, self-controlling, accepting responsibility, and seeking social support. There were fewer gender differences in perception of stressors than in coping strategies. Findings reflected the multidimensional aspects of stress and coping and the individuality of mothers and fathers in forming a configuration of the family coping system.

CURRENT HEALTH EDUCATION STRATEGIES AS RELATED TO CULTURAL DIVERSITY. James L. Darling & Veronica M. Acosta, Dept. of Health and Human Performance, Auburn Univ., Auburn, AL 36849

Health education in the United States must meet the challenges of a culturally diverse population. Many urge complete assimilation of these cultures into the "melting pot" of a homogenous educational system, while others propose individual recognition and accommodation of these different cultural elements as in a "salad bowl" analogy. There is a third and preferred analogy, that of a "stew pot", where the individual ethnic elements are surrounded by a health education process or "broth", which reflects the health needs of all citizens. Health educators must overcome ethnic and language barriers by: 1) communicating with target populations; 2) developing a knowledge of ethnic and racial groups; 3) realizing and overcoming personal prejudices; and 4) increasing their exposure to these culturally diverse groups. The members of these culturally diverse groups must also compromise and contribute to this exchange of information by: 1) assisting non-English speaking individuals as translators; 2) becoming involved in community outreach programs; and 3) participating in and advising health education curriculum committees.

## Abstracts

NURSING IN DESERT STORM:CONTEXT OF NURSING HISTORY. Kate Jackson.  
University of Alabama School of Nursing, UAB, Birmingham, AL  
35294-1210.

Federal support of nursing education has been observed with each of the major wars. Nurses stationed across the globe have made a difference in the recovery of sick and wounded soldiers. Mobile army medical units in both Korea and Vietnam brought sophisticated medical equipment and trained personnel to those in combat. In response to the August 2, 1990 invasion of Kuwait, the Department of Defense mobilized National Guard and deployed 12 hospital units to the Persian Gulf. Deployment created both psychological and physical problems due to separation and fears of chemical warfare and other risks. In Saudi Arabia, low humidity, blowing sands and general living conditions produced respiratory problems and with increasing proximity to war zone new sources of stress arose. Cultural barriers to nurses in a male dominated country were evident. Fortunately, the expected high casualty count did not occur and fighting was brief. Patients from U.S., Saudi and Iraqi forces, who were admitted to the unit were treated without respect to nationality, but, solely on seriousness of wounds. Orthopedic injuries and wounds from ammunition fragments predominated. Residual problems including environmental hazards of war and burning oil wells may have long-term effects. The mental consequences of uncertainty, incongruence of values and family and society reintegration difficulties are yet to be determined. Though war is the antithesis of medicine, those nurses who served in Operation Desert Storm did so to effectively restore principles of security and world peace. Our motto is "Army Nurses are Proud to Care."

PRIMARY EVALUATION OF GYNECOMASTIA IN AN ADOLESCENT.  
Milton S. Brasfield, IV, University of Alabama School of  
Medicine - Tuscaloosa Program, Tuscaloosa, AL 35487.  
Ilesha J. Brasfield, College of Human Environmental  
Sciences, University of Alabama, Tuscaloosa, AL 35487.

A case report and literature review are presented on a 13-year-old with gynecomastia. Developmental as well as medical manifestations are examined. Gynecomastia develops in 60-70% of adolescent males. While physiologic gynecomastia could be considered a normal finding, rare cases can be attributed to pathological causes. Initial evaluation should consist of a thorough history and physical exam. Timing of laboratory tests should be based on pertinent subjective and objective findings. While expensive work-ups can mostly be avoided, psychological and social issues should always be addressed.



## Abstracts

EXERCISE TRAINING EFFECTS ON METABOLIC STRESS TESTS OF PATIENTS WITH COPD. Patsy Riley, Capstone College of Nursing, The University of Alabama, Tuscaloosa, AL, 35487.

Patients who participated in a 12-week multidisciplinary pulmonary rehabilitation program were given treadmill metabolic stress tests prior to beginning and after completing the program. The sample of 15 consisted of 10 men and 5 women with a mean age of 67 years, mean packyears of 48 years, and were all Caucasian. Based on the data from the first stress test, an exercise program was planned for each patient. Specific exercises included walking on an indoor track, walking on a treadmill, climbing steps, turning an armcrank, rowing movement on a rowing machine, and arm movements of an exercise bicycle. Telemetry monitoring was used to continuously assess cardiac rate and rhythm during exercise. Blood pressure was monitored before, after, and during exercise if indicated. As patients increased strength and endurance, the exercise prescription was modified to include increasing activity and length of exercise time. After a cool down period, patients attended an education session on aspects of self-care in COPD.

Hypothesis 1 stated that there would be significant difference post exercise training in oxygen consumption ( $\text{VO}_2$ ),  $\text{CO}_2$  production ( $\text{VCO}_2$ ), oxygen pulse, minute ventilation (VE), and double product. The hypothesis was partially accepted with a significant difference found only in  $\text{VCO}_2$  ( $p=.041$ ). The second hypothesis that stated there would be a significant difference in length of time on the treadmill was accepted ( $p=.001$ ), a finding consistent with much of the literature. No significant difference was found in frequency or severity of desaturation or in pulmonary function measures.

HIGH ALTITUDE SICKNESS. Benton E. Gup, Ph.D., Dept. of Economics, Finance, and Legal Studies, and Robert E. Pieroni, M.D., Dept. of Internal Medicine and Family Practice, Univ. of Ala, University, AL 35487.

Despite clinical advances in knowledge of etiology, prevention and treatment of High Altitude Sickness, considerable morbidity and, unfortunately, occasional mortality, persist. "High Altitude" has been defined as heights of 1500 m - 3500 m (approximately 5000 to 11,500 feet), "very high altitude" as 3,500 m to 5,500 m (approximately 11,500 - 18,000 feet), and "extreme altitude" as over 5,500 m. Many medical problems have been described during ascent to high altitudes including acute hypoxia, acute mountain sickness (AMS), high altitude cerebral edema (HACE), and high altitude pulmonary edema (HAPE). We shall discuss our experiences at high (Colorado) and very high (Andes, Himalayas) altitudes with special emphasis on proper acclimatization, possible physical symptoms and their treatment, and reasons for variable tolerance to altitude sickness among individuals.

## Abstracts

NUTRITIONAL RISK FACTORS OF NONINSTITUTIONALIZED ELDERLY. Linda A. Streit, University of Alabama at Birmingham; Georgia Baptist College of Nursing, Atlanta, GA 30312

The rapidly increasing elderly population creates a multitude of challenges for nurses. The purpose of this descriptive correlational study was to ascertain the relationship between specified components of nutritional assessment (anthropometric measures and nutritional patterns) and nutritional risk factors in noninstitutionalized elderly persons. The study consisted of 81 subjects, 65 years of age or older who were living in housing facilities within the Southeastern United States. A 16-item instrument was used to determine whether an individual was considered at high risk for malnutrition or low risk for malnutrition. A 13-item instrument was used to measure nutritional pattern through dietary intake from 60 line-item foods. Demographic variables and anthropometric measures were also calculated. Analysis indicated that triceps skinfold thickness was found to be the highest discriminator for determining nutritional risk and that protein was the only nutrient which differed significantly between the high risk for malnutrition group and the low risk for malnutrition group. Weight and elbow breadth were determined to be the best predictors, within this population, for determining nutritional risk. However, this was a low level of predictability. Findings supported that anthropometric measures and nutritional patterns can be useful in determining nutritional risk among the noninstitutionalized elderly population. Future research is needed to determine additional variables which may assist in determining nutritional risk for this age group.

\*Entrant in the Student Research Awards Competition

DILANTIN TOXICITY: "THE PHENYTOIN SYNDROME".  
Robert E. Pieroni, M.D., Dept. of Internal Medicine and  
Family Practice, Univ. of Ala, University, AL 35487.

Although any medicine can result in untoward side effects, some drugs can occasionally be especially toxic, even in therapeutic dosages. Health care practitioners may not be aware of some potential toxic effects, and fail to rapidly discontinue the medicine after initial toxic manifestations. Although phenytoin (Dilantin) is a very effective anticonvulsant, it has frequently been used for a variety of other disorders in which its efficacy has not been established. Dilantin's most feared, yet frequently unrecognized side effect, is the "phenytoin syndrome." This can result in fever, severe rash, fulminant hepatitis, lymphoid hyperplasia, eosinophilia, blood dyscrasias, immunoglobulin abnormalities, and renal failure. Autoimmune disorders and cancers have also been reported. Features of several cases of the phenytoin syndrome we have encountered will be discussed with emphasis on prevention, patient characteristics, and available treatment modalities.

## Abstracts

THE VALIDITY OF THE CROWNE-MARLOWE SOCIAL DESIRABILITY SCALE AS INDICATED BY ENDORSEMENT OF TRAITS REGARDING THE SELF. Charles E. Joubert, Department of Psychology, University of North Alabama, Florence, AL 35632.

Sixty-one subjects rated 21 traits as being desirable or undesirable. Using an 80% agreement criterion, 11 traits were determined to be desirable and two were undesirable. A different set of 79 men and 137 women college students responded to the Crowne-Marlowe Social Desirability Scale and rated themselves on each of these 21 traits using six-point Likert scales. The results indicated that while men reported themselves as being more relaxed, creative, and introverted than did women, women reported themselves as being more cooperative, studious, religious, and trusting than did men. A correlational analysis indicated that both men and women who scored higher in social desirability described themselves as being more self-confident, trusting, studious, and sociable but less lazy and self-centered. Men who were high in social desirability described themselves as being more practical and less timid. Women who were high in social desirability described themselves as being happier, more cooperative, more tolerant, and more intelligent but less anxious. In the case of combined data for both sexes, persons who were higher in social desirability described themselves as being more relaxed, practical, trusting, cooperative, happy, sociable, studious, self-confident, and tolerant but less lazy, anxious, cynical, and self-centered. In general, these results suggested that the Crowne-Marlowe Social Desirability Scale does have a good deal of construct validity and that sex roles do influence social desirability perceptions.

DEVELOPMENTAL PROGRAMS AND REMEDIATION STRATEGIES IN SCHOOLS OF NURSING. Guice, E., Ford, D., Jacksonville State University, Jacksonville, AL

The presence of academically at-risk students who have been mainstreamed has created concern among administrators and faculty who are worried about attrition and meeting the students' needs. Many schools have put mechanisms in place to enhance these students opportunities for success and to better enable them to take care of patients with critical illnesses. This study was designed to describe developmental programs and remediation strategies in schools of nursing. A convenience sample (N=31) was drawn from all schools of nursing in a Southern State. Responses to questionnaires were tabulated using descriptive statistics. Over one half of schools surveyed reported no formal developmental programs. Strategies used for remediation were academic advisement, learning styles, group counseling, diagnostic testing, tutorial programs and remediation in math, reading and learning skills. Stress management strategies were also used. The findings imply that educators should plan programs for the at-risk student in order to reduce attrition and increase the number of competent graduates.



## Abstracts

THE DEVELOPMENT OF AN AGE-SPECIFIC DIABETES SELF-CARE BARRIERS TO SELF-CARE ASSESSMENT SCALE FOR OLDER ADULTS-A Pilot Study. Kuei-Shen Tu, School of Nursing, Univ. of AL. at Birmingham, Birmingham, AL 35294-1210.

Diabetes self-care is a complex regime and adherence to the regime by older adults is suboptimal. Barriers to practice self-care encountered by older diabetic adults have been related to psychosocial, functional, and cognitive factors. Few studies have systematically explored diabetes self-care barriers as perceived by older adults. The purpose of this study is to develop an age specific self-care barrier assessment scale for older diabetics (ASDSCBAS). A sixteen-item Likert scale with agree and disagree response format was developed to elicit diabetes self-care barriers relevant to dietary therapy, exercise, blood glucose monitoring as perceived by older adults. Eight-three older diabetics completed the questionnaire. Principal component procedure was used for data analysis. Varimax rotation produced a three factor solution which accounted for 47.1% of the total variance. Three areas of diabetes self-care were explicitly identified as problematic by the subjects: self-blood glucose monitoring, dietary regime, and physical activities. Cronbach's Alpha was .67 for internal consistency. The finding support ASDSCBAS as an instrument merits further investigation.

SELF-ESTEEM OF PREGNANT ADOLESCENTS AND ADOLESCENT MOTHERS. Portia Foster, College of Nursing, Jacksonville State University, Jacksonville, AL 36265.

A descriptive design was utilized to assess the self-esteem of pregnant adolescents and adolescent mothers. The conceptual framework was derived from Roy's Adaptation Model and the concept of self-esteem. The purpose of the study was to determine the level of self-esteem in adolescent females, aged fourteen to nineteen years. Female adolescents who reported that they were pregnant or had given birth to a live infant during their adolescent years were invited to participate in the study. A sample of fifty adolescent females living in two adjacent counties in a southeastern state participated. Subject's participation involved completing a self-esteem survey and an investigator-developed data questionnaire. The hypothesis was tested using appropriate statistical methods. Statistically significant differences were found in the self-esteem levels of the two groups. Implications from this study involve intervention planning and counseling needs. It is recommended that studies be conducted to identify variables that influence adolescents' self-esteem. It is further recommended that this study be replicated with different age groups and in several different geographical locations.

## Abstracts

BREAST CANCER CONTROL: BELIEFS AND USE AMONG BLACK AND WHITE WOMEN. Merrian E. Douglass, School of Nursing, Troy State University, Phenix City, AL 36869.

The purpose of this study was to identify differences between black and white women in beliefs about breast cancer and breast cancer control methods (mammogram (MAM), clinical breast examination (CBE), breast self-examination (BSE) and in the frequency of use of these methods. The Breast Cancer Control and Health Beliefs Questionnaire was used to collect data from 117 black and 157 white female professional educators. Subjects were 35 to 69 years of age and had no personal history of breast cancer. White subjects had a significantly higher mean score for barriers to MAM and CBE and for control with CBE. The difference in control with MAM and benefits of BSE reached borderline significance; with white women having the higher mean score for both beliefs. There was no significant difference in the frequency of use of MAM and CBE. The difference in frequency of use of BSE had borderline significance. Also, black subjects had performed BSE significantly more times than white subjects during the past 12 months. The relationship of beliefs about breast cancer and breast cancer control methods and use of these methods in black and white women is unclear, especially regarding BSE. Other explanatory variables should be considered. Implications of findings and recommendations for further study were presented.

OCCUPATIONAL MORTALITY IN ALABAMA - A PILOT STUDY. Susan G. Austin, ScD, and Ningyi Huang, MD, MSPH, Dept. of Epidemiology, University of Alabama - Birmingham, Birmingham, AL 35294.

This pilot study assessed the adequacy of available occupation and industry information generally, and applied proportional mortality (PMR) methodology to investigate the association between traumatic fatalities and employment in the agriculture industry. Computerized records of all Alabama death certificates to the five year period 1984-1988 were obtained from the Alabama Department of Health. PMR's were calculated for all causes of death, including deaths from external causes (ICD9 codes E800-E999) for each race and sex group within the group of 12,746 decedents whose "usual" industry was agriculture. Two sets of PMRs were generated; one based upon comparison with the US, and one based upon internal comparison with overall Alabama experience during the study period. Based upon the US comparison, PMRs for "All accidents" were significantly elevated in Alabama for all race and sex groups. Based upon the Alabama comparison, PMRs for "All accidents" continued to be significantly high for white male and non-white female agriculture workers (PMR = 114 and 151) and for non-white female farmers (PMR = 178). Other causes of death were significantly elevated in this occupational group and illustrate the feasibility of the PMR methodology for identifying potential occupational health concerns within occupation and industry groups in Alabama.

## Abstracts

CHARACTERISTICS OF ACADEMIC PHYSICIANS INTERESTED IN AGRIMEDICINE. John R. Wheat and M. Christine Nagy, Dept. of Behavioral and Community Medicine, Jerry T. McKnight and Russell L. Anderson, Dept. of Family Medicine, Univ. of Alabama, Tuscaloosa, 35487.

This study examined interest in agrimedicine among University of Alabama School of Medicine (UASOM) physicians and factors promoting this interest. Sixty-one of 140 (44%) UASOM clinical faculty provided information on interest in and experience with agrimedicine topics relative to teaching, conducting research, and treating patients; activities providing agrimedicine experience; and demographics. Most respondents specialized in Pediatrics (34%), Family Medicine (30%), Obstetrics/Gynecology (16%), and Medicine (10%). Respondents averaged 16.9 years of experience with 29% having practiced in small towns. Nearly half (48%) graduated from high schools in small towns and many (18%) had fewer than 50 classmates at high school graduation. Twenty-two (36%) reported an interest in agrimedicine. These physicians taught more topics ( $p=.02$ ), treated more problems ( $p=.01$ ), had more experiences related to agrimedicine ( $p<.001$ ) and were more frequently located at a branch campus ( $p=.02$ ). Background traits associated with this interest included small home town ( $p=.02$ ), small high school graduation class ( $p=.04$ ), previous practice in a small town ( $p=.01$ ), and Family Practice specialty ( $p<.001$ ). These same characteristics are associated with preparing doctors for rural practice. Co-existence of agrimedicine and family medicine could magnify impacts on agricultural populations.

THE RELATIONSHIP OF SELF-CONCEPT TO THE BODY SIZE, MOTOR ABILITY, GENDER, AND SCHOOL PERFORMANCE OF EXTREMELY LOW-BIRTH-WEIGHT SCHOOL-AGE CHILDREN. LaCrecia J. Britton, The Children's Hospital of Alabama, Birmingham, AL 35233.

The relationship of self-concept to the body size, motor ability, gender, and school performance of extremely low-birth-weight (ELBW) school-age children was examined with the completion of a secondary analysis of data obtained from a study in a low-birth-weight follow-up clinic. Subjects consisted of a group of 65 children, whose birth weights were less than or equal to 1,000 grams. These subjects were administered a battery of tests which included the Piers-Harris Self-concept Scale for Children, the National Center for Health Statistics percentiles, the Southern California Motor Accuracy Test-Revised, the Bruininks-Oseretsky Test of Motor Proficiency, the Wide-Range Achievement Test-Revised, and the Wechsler Intelligence Scale for Children-Revised. Statistical analysis consisted of stepwise multiple regression. The results revealed that ELBW school-age children with heavier body weight for age and low reading achievement had the lowest self-concept. This was particularly true for the male gender. There was no relationship between self-concept and motor ability. Consistent with recent research on self-concept, the findings support a relationship between self-concept and body weight, gender, and school performance.



## Abstracts

THE INCIDENCE OF THREE HABIT DISORDERS AMONG COLLEGE STUDENTS AND THEIR CORRELATIONS WITH TOBACCO AND CAFFEINE USAGE. Charles E. Joubert, Department of Psychology, University of North Alabama, Florence, AL 35632.

This study explored the incidence of three stereotype/habit disorders (nail-biting, nose-picking, and object-chewing) among normal college students and what correlates existed between these behaviors and popular tensional outlets. The 108 men and 202 women subjects reported the frequency in which they bit their fingernails, picked their noses, chewed on pencils or other objects, used specific tobacco products, used specific caffeine products, chewed gum, and exercised. Additionally, they reported their happiness by using a seven-point Likert scale. The incidence of fingernail-biting observed here was somewhat higher than was found in previous samples of young adults and had a significant sex difference: 47% of men and 34% of women were nail-biters. More men (49%) than women (21%) admitted to nose-picking on occasion. About 61% of persons of either sex reported being occasional object-chewers. Men were more likely to exercise, use tobacco products, or consume iced tea than were women; but less likely to chew gum. The sexes did not differ in terms of self-reported happiness. The intercorrelations among the habit disorders were not significant; and their occurrence did not relate to lower self-reports of happiness. Both men and women who reported chewing on objects on occasion reported greater quantities of cola consumption; otherwise, the relationships between the habit disorder and product usage were not significant.

JAMAICAN FOLK MEDICINE. Ladi Doonquah, B.S., and Robert E. Pieroni, M.D., Dept. of Internal Medicine and Family Practice, Univ. of Ala, University, AL 35487.

Jamaica, a part of the West Indies known as Greater Antilles, lies in the Caribbean Sea just south of Cuba. The vast majority of inhabitants are of African or mixed African and white ancestry. Although Western medicine has become increasingly utilized, folk medical practices are well ingrained among the population. These practices, many of African origin, are of varied scope and include numerous herbal remedies, use of animal parts (e.g., as aphrodisiacs), and religious incantations and ceremonies which blend ancient traditional with more modern orthodox medical practices. For example, obeah, a traditional Jamaican healing system, comparable to santeria and voodoo from other West Indian cultures, will be explained. We shall present an overview of Jamaican folk medicine practices with special emphasis on the reasons why its practitioners have gained such widespread support. Salubrious as well as potentially dangerous effects of such practices will be underscored.

## Abstracts

CRITICAL FACTORS IN THE ASSESSMENT OF HYPER-ANDROGENIC SYNDROMES IN WOMEN. Larry Boots, H. Downing Potter, and Ricardo Azziz, Department of OB/GYN, The University of Alabama at Birmingham, Birmingham, AL.

Of the many endocrine disorders relating to infertility in women, perhaps none require as much laboratory investigation as the various hyperandrogenic conditions. These hormonal imbalances most often result in hirsutism and often in amenorrhea, infertility and increased risk of heart disease and uterine cancer. Standard laboratory tests include testosterone (T), dehydroepiandrosterone (DH), DH-SO<sub>4</sub> and androstenedione. Even more important is the careful study of the status of testosterone binding in the circulation. The majority (97%) of circulating T is tightly bound to sex hormone binding globulin (SHBG) or loosely bound to albumin while about 3% is unbound. Traditionally, only the free fraction has been considered to be biologically active. An additional and possibly confounding problem is the fact that estradiol (E) also competes for binding sites on SHBG and may affect binding by T. Albumin-bound T/E may also be biologically active. It was the purpose of these studies to design assays capable of assessing the complete T and E picture in the circulation. The assay for measuring T and E bound to SHBG and free T and E were based on the measurement of actual T and E binding sites on SHBG. The technique is based on the principle of equilibrium dialysis utilizing Sephadex G-25. Albumin-bound T or E are determined by measuring the total amount of non-SHBG bound hormone and then subtracting that portion which is free. These techniques will hopefully aid in understanding the complex interactions of T and E in various hyperandrogenic conditions.

PERINATAL PERCEPTIONS OF NURSE CARING BEHAVIOR. Deborah M. Firman, Grad. School of Nursing, Univ. of Ala. at Birm., UAB, AL 35294. Deborah M. Firman.

A qualitative study was done to determine perinatal client perceptions of nonverbal nurse caring behavior; what behavior was considered caring or noncaring, and if there was a difference in acute (labor and delivery) vs. nonacute (post partum) care settings. Semistructured interviews were conducted and content analysis was used to identify 12 common caring and non-caring themes. Graphic and direct, along with open ended questions were used to enhance validity. The clients desired intimacy with their nurses in both settings, although lack of intimacy was less distressing in post partum than in labor and delivery. When intimate space was entered, the clients did not want the nurse to compensate with equilibrium behaviors, but instead desired a very high degree of intimacy with the nurse. The clients felt that the degree of intimacy the nurse maintained reflected the degree of caring, and lack of intimacy, non-caring. If the nurse was busy, it was viewed positively if he/she maintained intimacy nonverbally, despite a lack of physical presence. The patient perceived the busy nurse negatively if he/she blocked intimacy with nonverbal behaviors such as decreased eye-contact.

## Abstracts

FITNESS OF SCHOOL-AGE CHILDREN BASED ON ACTIVITY PATTERNS. Ann H. Johnson, MSN, RN, University of Alabama School of Nursing, UAB, Birmingham, AL 35294

A growing interest in the promotion of fitness of children has been demonstrated. Unfortunately, misconceptions regarding youth fitness remain. The purpose of this study was to ascertain if a relationship exists between activity pattern and cardiorespiratory (CR) fitness test performance of school-age children. The conceptual basis for the study was Orem's Theory of Self-Care. Activity pattern data were collected from the parents of 40 fifth-grade children using a physical activity survey. CR fitness of the children was assessed using a height-adjusted step test. Most of the parents rated their children as having average to high activity patterns. In contrast, parents also reported large amounts of television viewing by the children. Equal numbers of children performed at average and high levels of fitness. When the subjects were compared according to activity pattern and fitness level, there was no significant association between parental rating of activity and fitness, nor was there an association between weekday television viewing and fitness. There was a significant negative association between weight and fitness level. Fifth-grade children in this study were able to meet fitness self-care demands. Further study of fitness-related factors in children is needed.

CAREER CHOICE SATISFACTION AND CAREER MATURITY OF BACCALAUREATE NURSING STUDENTS. Joan B. Carlisle, DSN, RN, University of Alabama School of Nursing, UAB, Birmingham, AL 35294.

Career maturity (CM) is the readiness of an individual to meet the identified tasks of career development. Students with high career maturity will make wiser career decisions, thereby enhancing their self and career satisfaction. However, little is known regarding the pattern of CM throughout the nursing program. The purpose of this study was to describe career choice satisfaction (CCS) and CM of baccalaureate nursing students. Data were collected from students enrolled in three levels of nursing courses at a selected university. The CM Inventory Attitude Scale and a 10 point rating scale of satisfaction (1=least; 10=most) were used in this study. The mode satisfaction score was 10 with a range from 3 to 10. The median score was 9. The CM scores ranged from 25 to 46 (most mature score=50) with a mean of 37.5. No significant relationship was demonstrated between CCS and CM. Likewise, no difference was found in CM scores across levels of the program. Additionally, CCS scores were not significantly different among the three levels. Nurse educators should provide individual career guidance for students and identify strategies which promote CM throughout the nursing program. Future studies should focus on CM and CCS as new graduates move into the practice arena.



## Abstracts

THE EFFECTS OF SELECTED DRUGS OF ABUSE ON CATECHOLAMINE RELEASE FROM CULTURED PHEOCHROMOCYTOMA (PC-12) CELLS. J.J. Spollen; J.M. Beaton, Ph.D.; L.C. Tolbert, Ph.D. Department of Psychiatry and Behavioral Neurobiology, U.A.B. Station, Birmingham, AL. 35294.

Drug abuse has long been recognized as a problem in the United States, and recent opinion polls have shown that many Americans consider it to be the major problem confronting society today. Many of the illegally abused drugs produce CNS stimulating effects, e.g. excitation, euphoria, hallucinations, etc. A majority of these effects are mediated by the CNS catecholamines, dopamine (DA) and norepinephrine (NE). In this study we examined the effects of various drugs of abuse on the release of these neurotransmitters from cultured PC-12 cells. The compounds investigated were 4-aminorex ("ICE"), R- and S-2,5-dimethoxy-4-methyl-amphetamine (R-DOM, S-DOM, "STP"), methamphetamine ("CRANK"), d-amphetamine ("SPEED"), and mescaline. Sets of cells were incubated for thirty minutes with concentrations ranging from 1  $\mu$ M to 500  $\mu$ M of each compound. All compounds induced increased catecholamine release when compared to non-drug treated controls. The most dramatic and consistent effect was that of mescaline on DA release. Mescaline, at 500  $\mu$ M, produced a 250% increase in release compared to control. This increased release was greater than the total DA found in the lysed cell sample, suggesting an increase in the production of DA. S-DOM was found to be more potent than R-DOM in increasing the release of both NE and DA, consistent with the finding that S-DOM is a more potent hallucinogen. Our findings suggest that PC-12 cells are useful in testing compounds with CNS stimulating properties, and that such testing may give clues to the properties of an unknown drug.

David C. Hefelfinger, M.D., Dept/ of Pediatrics, College of Community Health Sciences, Univ. of Ala., University, AL 35487.

A study was undertaken to ascertain whether an increased incidence of Acute Rheumatic Fever (A.R.F.) was present in West Alabama, similar to reports elsewhere within the United States. Hospital records for the prior ten years were reviewed and five year intervals were contrasted (1980-84 to 1985-89). A sevenfold increase was noted in the later period, reflecting an increased incidence. Possible explanations for this increase were discussed. It was emphasized that confirmed close surveillance, appropriate testing, and adequate complete treatment must be continued to effectively deal with the eradication of streptococcal disease and Acute Rheumatic Fever.

## Abstracts

HOPE IN THE OLDER ADULT. Susan Gaskins & Linda Forte, Capstone College of Nursing, The University of Alabama, Tuscaloosa, AL 35487-0358

Hope has various attributes and meanings in the literature. The meaning used most often describes hope as a positive emotion, or views hope as an anticipation of a positive future. Hope is recognized as a necessary ingredient for well-being and for sustaining life. Additionally, hope is viewed as a source of meaning or value in one's life.

As the population of people over 65 increases, accompanied by changes in health status and the ability to care for oneself, it becomes essential to understand hope in this population. Hope is a part of the concept of caring in health care. While the nursing literature refers to the importance of maintaining, sustaining or restoring hope, there is little written about nursing actions to assist persons to achieve or maintain hope. The purpose of this study was to determine the meaning of hope in the elderly population.

Ten individuals over 65 years of age comprised the sample. The participants were given an automatic camera and asked to photograph sources of hope in their environments. The researchers returned with the photographs and asked the participants to interpret each photograph during an audiotaped interview.

The interviews were analyzed using a phenomenological approach. The aim of this research was to determine the meaning of hope to the participants. The sets of photographs and interpretive data were coded into categories. The initial categories to be identified included religious orientations, aesthetic orientations, patriotism, freedom, and relationships.

Implications from the study include the importance of nurses and other health care professionals recognizing what the sources of hope are in the elderly population. This information can be used to plan care and cultivate an environment that fosters hope. The study also has implications for the usefulness of photography in nursing research. Further research is recommended on sources of hope in other populations.

SLEEP APNEA. Mark Thomas, B.S., and Robert E. Pieroni, M.D. Dept. of Internal Medicine and Family Practice, Univ. of Ala, University, AL 35487.

Sleep apnea is a clinical syndrome which can consist of numerous apneic episodes, prominent snoring, sleep arousal, myoclonus, and daytime somnolence. Recent descriptions of impaired concentration and memory, and a variety of cognitive deficits and psychological disturbances, including dementia, have been described. Recently, an elderly male was referred to us for progressive memory loss. During a dementia workup it was noted that the patient had been experiencing severe obstructive sleep apnea. Nasal continuous positive airway pressure (CPAP) was instituted nightly with considerable symptom improvement. The need for consideration of sleep apnea in subjects with cognitive and psychological deficits merits a heightened awareness.

## Abstracts

TEEN PREGNANCY PREVENTION PROGRAMS IN HIGH-RISK AREAS: IDENTIFICATION, EXAMINATION, AND COMPARISONS. Rene Breland and Lane H. Powell, Department of Family and Consumer Education, Samford University, Birmingham, AL 35229.

The effectiveness of teen pregnancy programs is usually determined by how well the program addresses the major risk-factors leading to teen pregnancy. The purpose of this study, therefore, is three-fold: to identify the major risk-factors of teen pregnancy, to examine three pregnancy prevention programs in high-risk areas, and to compare the effectiveness of these programs. The three programs chosen represent various areas of the country, different philosophies, and different approaches to the problem of teen pregnancy. They are then examined in light of the high-risk factors identified. Finally, a comparison of these programs is made according to the extent that each major factor of teen pregnancy is addressed.

EFFECTS OF A FALLS PREVENTION PROGRAM ON SELECTED BEHAVIORS OF AMBULATORY OLDER ADULTS. Barbara Harbin, University of Alabama School of Nursing, Birmingham, AL 35294-1210.

This study was conducted to determine effects of a falls prevention program on (1) older adult's knowledge about falls, (2) their falls preventing behaviors, and (3) presence of falls hazards in their homes. A randomized pretest-posttest control group design was used. The 61 participants were partially blind to expected outcomes. Four instruments were used and data were collected by trained observers who were blind to program differences. Both intervention and placebo were administered by the investigator. The experimental group improved performance significantly more than the control group on the variables: walking shoe support, frequency of exercise and condition of the path to the bathroom.

POWER WITHIN: A CASE STUDY OF CANCER SURVIVAL. Debra Lay, and Nancy Hill, Div. of Nursing, Mississippi University for Women, Columbus, MS 39701.

The purpose of this case study was to discover, describe and analyze the phenomenon of cancer survival. Raw data was collected using an audio-taped interview. Analysis was done using the first four steps of Leininger's Six-Step Process for analysis-synthesis. The key theme identified was determined to be the Power Within. Survival was viewed as a process having five subthemes: Rationalization, Recognition, Relinquishing, Reclaiming, and Recovery.



## Abstracts

### ENGINEERING AND COMPUTER SCIENCES

Soil Liquefaction Potential for Road Embankments from Unusual Vehicle Excitation. Stan Vitton and Jay K. Lindly, Dept. of Civil Eng., Univ. of Ala., Tuscaloosa, AL 35487-0205.

Soil liquefaction is synonymous with earthquakes where it causes some of the most dramatic types of damage to structures resulting from earthquakes. In general, soil liquefaction develops when a loose saturated sand is subjected to ground motions that cause a decrease in the pore space of the sand's matrix; if drainage is delayed, a build up in pore pressure will occur. If this increase approximates the overburden pressure, the effective stress essentially becomes zero and the sand loses its strength and develops into a semi-liquid state. In this state the soil has only limited ability to maintain bearing loads. Soil liquefaction, however, is not only a phenomenon of earthquakes but can also develop from less obvious and considerably lower levels of ground vibration. This paper will present a case history and analysis of a flow slide due to soil liquefaction that was initiated by seismic exploration vehicles conducting a seismic reflection survey using vibratory tampers on a state highway along a Northern Michigan lake. The failure occurred when six 22 ton (196 kN) seismic trucks generating seismic signals liquefied the highway embankment causing a flow slide and the collapse of a 300 ft (91 m) section of the highway. Post-failure investigations of the failure revealed that the highway had been constructed on loose saturated sand, which had been hydraulically filled along the edge of the lake to create the highway's subgrade. At a different test site, ground motions were monitored in the vicinity of a 22 ton seismic truck as well as at depth. These measurements indicated that the shear strains generated by the tampers were sufficient to generate excess pore pressure that could lead to soil liquefaction. A slope stability analysis was conducted to estimate the shear strength of the embankment at failure. The results of this analysis indicated that the shear strength of the liquified soil was between 170 and 260 psf (8.1 and 12.4 Kn/m<sup>2</sup>), considerably below an estimated in-place shear strength of +600 psf ( $\phi_{res} = 38^\circ$ ). This shear strength loss is consistent with documented soil liquefaction failures and corroborates the assessment of a soil liquefaction failure.

MONOCLONAL ANTIBODIES TO PLATELET GLYCOPROTEIN IIb/IIIa: EMERGING THROMBOLYTIC AGENTS. Gladius Lewis, Dept. of Mechanical Engineering, Memphis State University, Memphis, TN 38152.

The glycoprotein (GP)IIb/IIIa complex is arguably the most important platelet-membrane-receptor. It is known to bind at least four different adhesive proteins or ligands (namely, fibrinogen, von Willebrand factor, fibronectin, and vitronectin), and is essential for aggregation to occur when platelets are activated by a variety of agonists. It is further known that GPIIb/IIIa is important in the direct attachment of platelets (adhesion) to subendothelium and collagen. Platelet aggregation, activation and adhesion are integral precursors to thrombus formation which, in turn, may induce a variety of life-threatening events, such as acute myocardial infarction, strokes, and peripheral ischemia. It follows, therefore, that an identification of monoclonal antibodies specific to GPIIb/IIIa will have important implications for thrombosis research and clinical applications. These antibodies may be useful as thrombolytic agents. The present study focuses on the use of ELISA (enzyme-linked immunosorbent assay) in the quantification of the attachment of two such antibodies to GPIIb/IIIa (namely, D3 GP3 and 7E3) which is adsorbed on polystyrene.

## Abstracts

### Characterization of Defects in Graphite Fiber Based Composite Structures Using the Acoustic Impact Technique.

J. R. Patel, U. K. Vaidya, and P. K. Raju, Dept. of Mechanical Engineering, Auburn University, Auburn, AL 36849.

Acoustic Impact Technique (AIT) commonly known as 'coin-tapping' has been applied by previous investigators as a nondestructive evaluation technique to study disbands in composite honeycomb structures. The experimental configuration adopted by previous investigators was somewhat restricted. In this study, a different approach to AIT is developed. This was done to overcome the experimental constraints encountered in the previous approaches. This paper presents experimental results obtained in the evaluation of defects 'commonly' found in graphite based composite structures, such as delamination, fiber break, and misaligned fibers. The experimental approach adopted in this work has two main features. Primarily, the force-time history of the specimen's response to a low magnitude input pulse in different regions of the specimen is compared. Secondly, an Acoustic Emission (AE) wide band sensor was used in conjunction with the conventional acoustic impact technique. The combination of the AE sensor and AIT enable the study of the material interaction with stress waves generated in the vicinity of the tapped region. Gross defects such as delaminations were identified through the change in the pulse width of the force input, while defects such as fiber breakage and misaligned fibers were successfully identified using AIT in conjunction with AE.

### AN ASSESSMENT OF REUSE POTENTIAL FOR ASH FROM COAL-FIRED POWER PLANTS. Robert A. Schaffeld and James V. Walters, Dept. of Civil Eng., Univ. of Ala., Tuscaloosa, AL 35487-0205

Current projections predict a doubling of the nation's coal consumption in the next ten years. This increase in consumption will create a proportional increase in the production and the subsequent storage of coal ash. With this growth, coal-using utilities face increasingly tough environmental regulations, higher handling and disposal costs, and diminishing space for disposal areas. Ash utilization, therefore, can be beneficial through generated income, avoided disposal costs, and less severe environmental regulations than those applied to disposal. Potential applications for bottom ash include aggregate for road surfacing and lightweight concrete block production. Fly ash applications include: use as a mineral filler in asphalt-paving production, use as a sub-base support layer under a clay liner in landfill lining, and use as a cement replacement in ready-mix concrete production. Strict specifications for each potential application regulate the physical and chemical properties necessary for the ash to be acceptable for use. Stored quantities of both fly ash and bottom ash are relatively large and geographically diverse. Exhibiting the desired properties, ash from coal-fired power plants can compete with the costs of currently used materials. The benefits of ash utilization should, therefore, prompt the utilities to view ash as a resource and to market it as such.



## Abstracts

MODELLING TRAFFIC ACCIDENTS ON OBJECT-ORIENTED INTELLIGENT DATABASE SYSTEM. Gopalakrishnan R. Keertinagar, Department of Computer Science, The Univ. of Ala., Tuscaloosa, AL 35487

The primary purpose of this paper is the incorporate “creative thinking” into databases. *Data Mining* is a concept where software can be applied to a database which will identify specific characteristics within the environment which that database reflects. If the specific characteristics we seek are “problems”, then the general data mining application that we have outlined might be called a “problem identification”. The traffic accidents of Alabama present a typical scenario where data can be processed and refined utilizing a multitude of attributes. This project will interface between the front-end, the User-Interface or the Inference Engine, and the back-end, where data is mined using object-oriented models. After the raw database has been processed into classes and objects, a fact base is created, which is used to support the user interface rather than the original database. The user through the Inference Engine poses queries which are formulated into rule-bases to build a knowledge base. All of this is to support the automatic generation of high potential areas for counter-measure implementations for sets and their complements, which, for this application will typically be alcohol, bicycle, pedestrian and other types of accidents. This project will refine the subsets and will be able to extract information that is hidden otherwise. This project will use the latest techniques toward achieving this goal. The objective is to design and develop software which has the capability of automatically performing problem identification for a given database, and then generalize this to be applicable to most other databases.

TUSCALOOSA AND THE U.S.G.S. COOPERATE TO PROTECT LAKE TUSCALOOSA. James V. Walters, Dept. of Civil Eng., Univ. of Ala., Tuscaloosa, AL 35487-0205

Lake Tuscaloosa, on North River provides Tuscaloosa, Alabama, one of the most excellent water supplies in the world. Its dependable yield from the lightly inhabited basin exceeds the foreseeable demands of the next many decades. When it became apparent during the last decade that development in the area might affect the lake's water quality, the city of Tuscaloosa sought the cooperative assistance of the U.S. Geological Survey so that the nature of the water resource could be defined through study, and the water quality could be protected through knowledgeable monitoring of the factors affecting it. That cooperation has continued and has allowed the use of several protective actions and procedures. In the planned annual programs the first studies were directed toward defining the nature of the qualities and quantity of the resource in more detail. Subsequent studies were of the effects of agriculture and silviculture as they might be adding pesticides of insecticides to the lake. Later programs were devoted to studies of the major tributaries of the lake. That information was very helpful when a neighboring municipality began seeking to use water from Lake Tuscaloosa drainage area for its own water supply. This exemplary cooperation between the federal and local agencies is one that must be used to its full potential to demonstrate what synergy is possible in the use of tight funds for our resource protection.



## Abstracts

OBJECT-BASED SYSTEM MODELING. David Cordes, Department of Computer Science, University of Alabama, Tuscaloosa, Alabama, 35487-2090.

Recent developments in software development promote an object-based paradigm for software construction. Languages such as Ada and C++ have played a role in this shift, as applications developers now have at their disposal languages that 'support' such object-based development. However, simply providing a language that supports object-based development does not turn programmers into 'object-oriented software engineers.' Instead, what we find is that a large percentage of the population is generating conventional functional or data-flow designs and implementing these designs in an object-based language. The development strategy has not changed, only the implementation language. The resulting programs are not *object-oriented software*, and the benefits of the object-oriented paradigm (such as re-usability) are not realized. This presentation will address the issues inherent to the development of object-oriented software. Proper construction of object-based software must start with the initial phases of system analysis. The software specification and design must proceed in an object-based manner from its initiation. Furthermore, this process should be augmented by other, existing design techniques. Specific emphasis will be placed on the methods for the modeling and specification of software systems that incorporate object-based techniques. An analysis and review of these methods is presented, along with a critique.

VISUALIZING THE NEURAL NETWORK PHENOMENON OF LEARNING. Rustom Kersasp Vachha, Warren T. Jones, Department of Computer and Information Sciences, University of Alabama at Birmingham, AL 35294.

The promise shown by Artificial Neural Networks (ANN) as prospective pattern recognition paradigms has paved the way for its intense research. As neural networks become more complex in size and detail of their architecture, it becomes increasingly difficult to interpret their voluminous generated data efficiently and effectively. Various approaches have been suggested among them being a strategy to *visualize* the network's dynamic physical structure and the characteristics of its generated data. Our team is working towards building a visualization system for a neural network based on the backpropagation paradigm of learning. This system will assist current neural network research done at our university in visualizing the data pertinent to their study. Particular interest will be paid to visualizing the dynamic structure of the network as the training progresses. The size and color of nodes in the displayed network will vary in proportion to their activity. The strength of the interconnecting weights, which change dynamically during learning can also be visually perceived to alter in size and color tantamount to their magnitude. However, scientific visualization's main benefit for neural networks is realized when data obtained from the network during training is filtered or transformed into a form that exhibits more perception. This is conveniently done by manipulating the data, usually the level of error during training, to form isosurfaces and 3D or contour plots using the Application Visualization System (AVS) to usefully interpret how well the network is trained. Through AVS we also offer various image processing features that manipulate the visualized data and elicit further information from parts of the image that are more interesting to the observer.

## Abstracts

### Initial Weights Calculation For Backpropagation Neural Network Training

FAIZAL ELEDATH, Dept. of Computer Science,  
University of Alabama at Birmingham, AL - 35205.

One of the major bottleneck to the development of *Artificial Neural Network* (ANN) practical applications has been the *training/learning* problem. At present training ANN is both expensive and time consuming. Knowing how to select the input information, how to choose the training sets, and how to do preprocessing of data are not straightforward and are poorly understood. If this problem can be tackled an avalanche of new possibilities and application will arise. A method based on initial weights calculations is proposed to reduce the training time.

A two-layered feedforward ANN has been proven capable of approximating any arbitrary function given that there are sufficient numbers of nodes in the hidden layers. The *backpropagation* algorithm is too slow and requires a longer training time for many practical applications. One reason for this is since the initial connection weights and hidden node biases of the ANN take random values, a *poor* choice of random values will result in a longer convergent time. Therefore it would be desirable to *calculate* the initial connection weights and the node biases using some heuristic, so that the convergence time is improved. One such strategy is explored in this paper. The developed strategy was tested using SINE, XOR, and 2-SINE problems and an improvement by a factor of 17, 3 and 5 respectively was observed.

A NEURAL NETWORK MODEL TO STORE AND RECALL A SEQUENCE OF INSTRUCTIONS. Vivek Anumolu and Kevin D. Reilly, Dept. of Computer and Information Sciences; Norman W. Bray, Dept. of Psychology, University of Alabama at Birmingham, Birmingham, AL35294.

In separate psychological studies by Bray (one of the authors) and his associates, non-retarded children as well as mentally retarded children are tested for use of external strategies in memorizing sequences of instructions. Each instruction involves matching of one of few objects with one of several targets. We present here preliminary modeling studies to simulate the subjects' behavior using neural networks.

The first neural network model is a variation of Grossberg's model(1978) for serial learning. Strong forward chains and weak backward chains are desirable for the correct self-driven recall of instructions in proper sequence. Our model accomplishes this by incorporating a post-synaptic threshold in the learning rule. Edelman(1987) has previously shown that such a threshold is biologically plausible.

The first model is embedded into a second model which learns to associate instruction units with representations of targets and objects. Here an "upper" network generates temporal sequences and activates cognitive maps in a "lower" network. Problems related to the correct associations of objects with targets are discussed.



## Abstracts

### DYNAMIC CREATION OF AN OPTIMAL ARCHITECTURE IN AN EFFICIENT TRAINING SCHEME FOR A FEED FORWARD NETWORK.

Nikhil Umrani, Dr. W. T. Jones. Dept. of Computer and Information Science, University of Alabama at Birmingham, AL-35294.

Neural networks are information processing systems, that extract information by working on the input, and produce an output from this information through a training process. The backpropagation algorithm is a popular training algorithm, which can be made more effective, if its computationally intensive nature is modified so as to bring down the actual time, required to train the network. This research suggests the use of a modified training algorithm, which reduces the computational intensity, by progressively training parts of the architecture, as opposed to the entire network. This is accomplished by beginning the training process with a network consisting of a single hidden unit, and modifying the architecture thereafter by adding new hidden units, as and when the previous architecture displays inability to learn further. Training is carried out on certain parts of the modified architecture only (the newly added hidden units).

### ALTERNATIVE DESIGN AND DEVELOPMENT STRATEGIES FOR COMPUTER DATA PROCESSING SOFTWARE. Sumant G. Chaudhari and Allen S. Parrish, Dept. of Computer Science, Univ. of Ala., Tuscaloosa, AL 35487-0290.

A well-known class of problems in data processing involves file update. The traditional development approach for this class of problems involves functional design implemented in the programming language COBOL. This presentation describes a new development approach for this class of problems based on object-oriented design, and whose primary objective is to maximize reusability of software components. This approach has been implemented in the programming language Ada, using generic packages to implement reusable components oriented toward update, retrieval, and formatting of data.

### CONTROLLING THE TRANSMISSION OF DRINKING-WATER-BORNE, INFECTIOUS DISEASE. L. Faye Jones and James V. Walters, Dept. of Civil Eng., Univ. of Ala., Tuscaloosa, AL 35487-0205

Outbreaks of infectious disease spread by contaminated drinking water still occur with disturbing frequency in the United States despite the progress that has been made in water treatment. Along with disinfection, which is still the most important control mechanism, emphasis also must be placed on the proper design and operation of water treatment processes which preceded disinfection and on the protection of the source of the raw water. This paper presents the control concepts developed from outbreak investigations, current statistics for water-borne disease outbreaks, and the etiologic agents identified in outbreaks.



## Abstracts

### ANTHROPOLOGY

NEZ PERCE: THE KEY TO THEIR ECONOMY. Keith Absher, Dept. of Marketing, Univ. of North Ala., Florence, AL 35632.

I was less than one hundred years in which the Nez Perce Indians changed their life pattern from fishermen and farmers to nomadic hunters. They roamed from the Snake River to Montana, hunting the buffalo they depended on for their livelihood. It was the acquisition of the horse that changed their life pattern so quickly. As Dr. Francis Haines states, "It is noteworthy when we realize that no other primitive people in all of history every adopted such a practice without instruction or supervision by more civilized people." It is not really known who taught the Nez Perce the art of selective breeding, or how to geld inferior stallions. When Lewis and Clark passed through this territory they found the Indian method of gelding horses far superior to that used by Virginia planters. The horses recovered from the operation far quicker with little swelling or infection. In the journal of Meriwether Lewis we find the following entry regarding the Nez Perce stock: "...some of the Nez Perce lofty elegantly formed active and durable horses were pied with large spots of white irregularly scattered and intermixed with black or brown or some other dark colour."

ARCHAEOLOGICAL SURVEY OF SELECTED TIMBER SALES TRACKS ON PORTIONS OF FORT MCCLELLAN'S PELHAM RANGE, CALHOUN COUNTY, ALABAMA. Curtis E. Hill, Jacksonville State University, Jacksonville, Alabama, 36265.

As of June 1991, the Archaeological Resource Laboratory has been under contract from the Department of United States Army at Fort McClellan to survey selected timber tracts for potential archaeological cultural resources. The survey area consisted of 5000 acres selected by environmental officers which could possibly be impacted during the timbering process. The primary goals of the survey were to generate site locational and artifactual data while bringing the sites to the attention of Fort McClellan's environmental officers. To date there have been over 50 cultural resources located and documented within the project area. A substantial amount of artifactual materials were recovered indicating a temporal span from transitional Paleo Period through early historic settlements. The archaeological investigation of the Fort McClellan property has been a successful and informative venture between Jacksonville State Archaeological Resource Laboratory and the United States Army. The archaeological data obtained thus far can only further enhance our knowledge of Fort McClellan's rich and varied past.

## Abstracts

RECONSTRUCTING THE BLACK BELT ENVIRONMENT USING LEAF IMPRESSIONS IN DAUB. Evan Peacock, U.S.D.A. Forest Service, Rt. 1 Box 98A, Ackerman, MS 39735.

The Black Belt, like much of the Southeast, is an area where preservation of pollen is poor. Reconstructions of the pre-Contact environment have thus relied largely on studies of the original land survey notes, which date to the first half of the 19th century. One avenue of information which has remained unexplored is the analysis of fired clay from the remains of prehistoric houses. This daub, or hardened earth plaster, often contains the impressions of plants and gastropods which were incidental inclusions in the clay. An analysis of daub from two prehistoric sites dating from the 13th to 15th centuries A.D. has yielded environmental information from the western edge of the Black Belt. Abundant leaf impressions and gastropod casts show that tree cover at that time was oak-dominated deciduous forest, with more pine having been present than is indicated in the land survey notes. The results of this study demonstrate that daub analysis can provide an accurate picture of the environment as it was centuries before the land surveys were carried out. The method holds great promise for environmental reconstruction and for understanding the impact of aboriginal agriculture upon the landscape. The large amounts of curated daub from sites across the Southeast make this a resource too valuable to ignore.

ARCHAEOLOGICAL PHASE II INVESTIGATIONS OF FOUR ARCHAEOLOGICAL SITES ALONG THE PROPOSED RIGHT-OF-WAY OF THE U.S. 278 BUTTAHATCHEE RIVER BRIDGE PROJECT (F - 380 (18) AND ER - 380 (17)), MARION COUNTY, ALABAMA. Adam Cleveland. Jacksonville State University.

During the months of July and August of 1991, a Phase II Archaeological Test Excavation was conducted on four archaeological sites along the Buttahatchee River, east of the city of Hamilton, Marion County, Alabama. The test excavation was conducted in cooperation with the Alabama Highway Department for the proposed right-of-way for the new U.S. 278 Bridge; Project (F - 380 (18) and ER - 380 (17)). 1Mr113, 1Mr114, 1Mr115 and 1Mr116 yielded archaeological materials indicating short - term hunting and gathering - related activity by Aboriginal populations. Based on the recovered bifaces and ceramic sherd, this temporally indicates this portion of the Buttahatchee River Valley was frequented by Aboriginal populations of the Late Archaic time period and continued to be visited up into the Middle Woodland time period. This as well as other excavations along the Buttahatchee River has given us a greater insight into the Aborigines who first occupied this region.

## Abstracts

THE ARCHAEOLOGY OF DUST CAVE: 1989 THROUGH 1991 SEASONS. Boyce N. Driskell, Division of Archaeology, University of Alabama, Tuscaloosa, AL 36587.

Test excavations at Dust Cave reveal an archaeological sequence dating from about 10,500 B.P. to 5,000 B.P. embedded within a deep, complex and finely laminated stratigraphy developed and preserved under dry conditions inside the cave. Four major archaeological components representative of Big Sandy Horizon (9,500-10,500 B.P.), Kirk Stemmed Horizon (8,000-7,000 B.P.), Eva/Morrow Mountain Horizon (7,000-6,000 B.P.), and Seven Mile Island Phase (5,600-5,000 B.P.) are present in the cave. Beginning in the summer of 1992, a five year excavation is planned which will result in excavation of most of the deposits. Although microstratigraphy and organic remains are still well preserved, the higher water table and additional dampness resulting from inundation of Pickwick Lake will no doubt eventually destroy any remaining deposits. Excavation strategy will emphasize 1) recovery of a large sample of organic remains through flotation and fine screening techniques, and 2) careful excavation by natural levels to enhance contextual interpretation.

THE EVOLUTION OF HEALTH CARE DELIVERY IN A RURAL COSTA RICAN COMMUNITY: PEJIBAYE, 1942-1991. James Sewastynowicz, Dept. of Geography-Anthropology, Jacksonville State Univ., Jacksonville, AL 36265.

Following a successful liberal revolution in 1948, Costa Rica embarked on a program of social welfare designed to redistribute the national wealth and provide for the basic needs of all its citizenry. Among other things, this has included an ambitious program of socialized medicine. This paper examines the impact of government policy on one rural community located in the southwestern part of the country, tracing its evolution from an isolated frontier settlement to one increasingly dependent on government assistance in a myriad of forms, including medical care. The effectiveness of socialized medicine and the problems attendant to this system are also examined.

Faunal Remains from Dust Cave. Jennifer Grover, Dept. of Anthropology, University of Alabama, 19 ten Hoor Hall, Tuscaloosa, Al., 35487.

Test Excavations at Dust Cave, by the University of Alabama and the University of North Alabama, have revealed four meters of cave deposits the caover the Early (10,000-8,000 B.P.) and Middle (8,000-6,000) Holocene. One of the unique features of these deposits lies in the fact that they contain the largest faunal collections of the Early Holocene in the Middle Tennessee Valley. Given this, the collection is being studied, not only to provide an analysis of the faunal remains, but with hopes of shedding additional light on the cultural changes that occurred between the Early and Middle Holocene.



## Abstracts

IN SEARCH OF SIXTEENTH CENTURY COOSA, THE HURLEY SITE (1Cel37).  
Harry Holstein, Jacksonville State University, Jacksonville,  
Alabama.

The reinvestigation of archaeological data from the Weiss Basin Hurley Site (1Cel37) has provided additional evidence indicating the location of the 16th Century principle town of Coosa as being situated at the confluence of the Chattooga and Coosa Rivers in Northeast Alabama. Weiss phase ceramics, early historic artifacts, and fieldnotes indicate a substantial photohistoric Aboriginal village on the left bank of the Chattooga River. Researchers believe the Hurley Site represents but a portion of the large settlement of Coosa. The Seven Springs Site (1Cel01) located on the right bank of the Chattooga River across from the Hurley Site and the Bradford Ferry Site (1Cel73) across the Coosa River from both sites represent archaeological contemporary data for being other portions of this important Aboriginal town.

MICROWEAR ANALYSIS OF STONE DRILL BITS FROM THE BRIDGEPORT SITE (1JA574), JACKSON COUNTY, ALABAMA. Marla Jo Spry, Division of Archaeology, Univ. of Ala., Tuscaloosa, AL 36587.

Late Woodland trench excavations along the southeastern margin of the Jackson County Bridgeport site obtained a substantial number of chipped stone drill bits. Microwear analysis of the lithic tools proposes to reveal the use modes of the artifacts. The previous functions of the artifacts are determined by examining the surface of the chipped stone under microscopic magnification. Continual use of the tools altered the stone's natural topography. Microscars, linear features, and polish exhibit patterns that are characteristic of various work modes and distinguish the materials of contact. These methods have been applied to the analysis of the drill bits recovered from the Bridgeport site.

HEALTH CARE, HOUSEHOLD RESOURCES, AND THE PERUVIAN ECONOMIC CRISIS. Kathryn S. Oths, Dept. of Anthropology, Univ. of Alabama, Tuscaloosa, AL 35487

It has long been held by many health researchers that cost is the primary factor determining the choice of modern medical treatment for third world people. This paper concerns the change observed in patterns of treatment resort to healers when household resources suddenly became scarce for Andean highlanders at the onset of the recent Peruvian economic depression. Contrary to what might be expected, when already meager incomes became even more limited with the crisis, people did not curtail use of biomedical options in favor of traditional healers. Rather, they utilized somewhat fewer of all types of healers, but significantly fewer traditional ones. The sharp drop in the use of traditional medicine is shown to be related to the severity of illness in a rather surprising way.

## MINUTES

ALABAMA ACADEMY OF SCIENCE  
ALABAMA JUNIOR ACADEMY OF SCIENCE  
JOINT BUSINESS MEETING  
BRYANT CONFERENCE CENTER  
UNIVERSITY OF ALABAMA, TUSCALOOSA, AL  
April 17, 1992

1. Dr. Ken Marion, President of AAS, called the meeting to order at 6:00 p.m.

2. The President called for the report of the Counselor to AJAS, Dr. Eugene Omasta. The following written report was presented:

The AJAS has a full schedule of activities planned for the annual meeting, including: the paper competition among 45 regional winners, a program at the Alabama Museum of Natural History, the caucus and election of state officers, presentation of awards, the joint banquet, a dance and the Saturday rap session with our banquet speaker, Dr. Gibbons. At this time, 170 students have pre-registered for the meeting and 167 plan to attend the joint banquet.

The winners of the scientific paper competition were:

Physical Science	1st Place: Kris Thiessen, Athens 2nd Place: Mark Spencer, Auburn Most Creative/Least Resources: Mark Spencer, Auburn
Biology	1st Place: Loren Looger, Randolph 2nd Place: Will Stowe, RLC Most Creative/Least Resources: Will Stowe, RLC
Humanities	1st Place: Jennifer L. Hedrick, RLC 2nd Place: Braden Phillips, Huffman Most Creative/Least Resources: Braden Phillips, Huffman
Engineering	1st Place: Lisa Jackson, Lanier 2nd Place: Daryl Martin, Austin Most Creative/Least Resources: Andy Bestor, Brewer

## Minutes

### Mathematics

\*1st Place: Michael Tehranchi, Vestavia

2nd Place: Dawn Jones, Lanier

Most Creative/Least Resources: Michael Tehranchi, Vestavia

\*Overall winner who will represent Alabama in the paper competition that is a part of the National JSHS Symposium at Knoxville, Tennessee, May 8-10, 1992. The other 1st Place winners will accompany Michael on this expense paid trip.

### Other awards were:

Army Award: \$300 for supplies and a certificate - Teacher-sponsor of the overall winner: Kay Tipton, Vestavia Hills

Expense paid trips to the National Symposium at Fort Monroe, Virginia: Kay Tipton, Vestavia Hills

### Grant for a research project:

Chris Thiessen, Athens

Berry Nall, Escambia County

Mamie Thomas, Sumpter County

### Scholarship - \$150

Marlo Nall, Escambia County

### Outstanding Region - An engraved plaque:

Central - Regional Counselor, Fannie Nelson

### Newly elected officers for 1992-93

President - Ketrick Williams, Escambia County

Vice-President - Mamie Thomas, Sumpter County

Treasurer - Christopher Thomaskutty, Brewer

Secretary - Melody Hudson, Mary B. Montgomery

Many people deserve special thanks for their efforts in support of the 1992 annual meeting, including: Jeff Richetto for serving as local arrangements person in making plans and arrangements for the meeting rooms, motel rooms, tours, and in planning and assisting AJAS at this meeting; Barbara Kimbrell as Regional Counselor of the host West Region and her students from that region, in arranging the dance, gathering gifts and materials for the students from local merchants, assisting with



## Minutes

registration, and planning and assisting with the meeting; the state officers for their support and assistance - Kristy Thomaskutty (President), Cooper McDonald (Vice-President), Marlo Nall (Treasurer, and Melody Hudson (Secretary). The officers deserve special credit for designing this year's T-shirt in the colors of the host institution. Also, special appreciation is extended to the judges of the paper competition for both judging and their concern for student scientific development - Anna Smith and Bill Smith from Troy State University; Fred Gabrielson, Hank Kallsen, Don Gumprecht, Karen Inman, Brown Hawkins, William K. Rey, TsunZee Mai, Carol Yeager and Anthony Schaffer from the University of Alabama, Elsie Spencer from Opp High School; and also the associate counselors for their continued dedicated service to AJAS - Betty Bigham and B.J. Bateman.

The continued support of the Senior Academy in AJAS activities is appreciated. We especially appreciate the support of this years' President, Ken Marion and the Executive Officer, Levin Hazelgrove.

3. The President called for the report of the Coordinator of Science Fairs. Ms. Rosie McKinney reported that the 1992 ISEF trip to Nashville is being organized. The official list of participants has yet to be prepared.

4. The President asked for the report of the Science Olympiad Coordinator. Dr. Steven Carey reported as follows:

In 1992, 90 Division C teams and 53 Division B teams competed in regional tournaments. Eighteen Division C and a Division B teams will compete at the state tournament. Also in 1992, Auburn University will host the National Science Olympiad.

5. The President called for the report of the Gorgas Foundation. Dr. Leven Hazelgrove presented the following report:

The Gorgas Scholarship Foundation announced today the ranking of the finalists in the 1992 Alabama Science Talent Search. The Search was held at the meeting of the Alabama Academy of Science at the University of Alabama, Tuscaloosa, Alabama.

The winner of the first-place tuition grant of \$2500 was:

Loren Lee Looger, 1104 Mahan Drive, Madison, AL 35758. Randolph High School. Barbara Vought - Teacher.

First alternate and winner of a \$1500 tuition grant was:

Dennis Chang, 1312 Joshua Drive, Huntsville, AL 35803. Virgil I. Grissom High School. Randy L. Long - Teacher.

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Second alternate and winner of a \$1000 tuition grant was:

Christina Elizabeth Gargiulo, 3449 Moss Brook Lane, Birmingham, AL 35243. Resource Learning Center. Trudy S. Anderson, Ed. D. - Teacher.

Third alternate was: Kelly Parker Hyde, Route 7, Box 72, Florence, AL 35630. Brooks High School. Wanda Phillips - Teacher.

Fourth alternate was: Timothy Chien, 1905 Beechwood Circle, Florence, AL 35630. Henry A. Bradshaw High School. Cynthia Tillery - Teacher.

Fifth alternate was: Laura Michelle Gaunder, 228 Sequoia Boulevard, Florence, AL 35630. Henry A. Bradshaw High School. Cynthia Tillery - Teacher.

Sixth alternate was: Ann Elizabeth Gilliland, P.O. Box 879, Russellville, AL 35653. Russellville High School. Maureen K. Murphy - Teacher.

Seventh alternate was: Daymond Wayne Hughes, Route 12, Box 243-A, Florence, AL 35633. Central High School. Melonie Hanson -Teacher.

Eighth alternate was: Gina Marie Douglass, P.O. Box 298, Killen, AL 35645. Brooks High School. Wanda Phillips - Teacher.

Ninth alternate was: Justin Cooper McDonald, 2635 Nichols Drive, Athens, AL 35611. Athens High School. Emily Clem - Teacher.

Tenth alternate was: Anne Catherine Stumpe, Route 11, Box 44, Florence, AL 35630. Bradshaw High School. Cynthia Tillery - Teacher.

Eleventh alternate was: Emmitt Randolph Jolly , P.O. Box 96, Shorter, AL 36075. Booker T. Washington High School. Carol Harrison - Teacher.

Unable to exhibit was: Tomas Oscar Hook, 129 Stevens Hill Circle, Birmingham, AL 35244. Shades Valley Resource Learning Center. Trudy S. Anderson, Ed. D. - Teacher.

The rankings were established by a panel of judges consisting of department heads, deans, and professors from many of the leading universities and industries in Alabama.

Winners and finalists in the Gorgas Contests receive offers of tuition scholarships to colleges and universities in Alabama for the study of science. The Gorgas Foundation is named for General William Crawford Gorgas, the Alabama physician who conquered yellow fever in the Panama Canal Zone and later became

## Minutes

the Surgeon General of the U.S. Army. The purposes of the Foundation are to promote interest in science and to aid in the education of promising students.

6. The President called for the report of the Secretary. Dr. Larry Boots reported the following:

Membership, March 5, 1991	.	.	.	.	.	.	.	872
Members dropped for non-payment of dues, March 30, 1992	.	.	.	.	.	.	.	349
New members added	.	.	.	.	.	.	.	205
<hr/>								
Total membership, April 22, 1992	.	.	.	.	.	.	.	728
(net difference since March, 1990 = -144)								

### MEMBERSHIP BY SECTIONS

<u>Section</u>	<u>Dropped</u>	<u>Added</u>	<u>Diff.</u>	<u>Total</u>
1. Biological Sciences	100	17	-83	155
2. Chemistry	21	13	-8	82
3. Geology	19	3	-16	25
4. Forestry, Geography, etc.	11	7	-4	21
5. Physics & Mathematics	25	5	-20	76
6. Industry & Economics	22	9	-13	29
7. Science Education	16	5	-11	27
8. Social Sciences	32	3	-29	25
9. Health Sciences	58	22	-36	101
10. Engineering & Comp. Sciences	26	11	-15	44
11. Anthropology	13	5	-8	13
99. Industry, Politicans, etc.	13	2	-11	11
77. Libraries-University				26
88. Libraries-High School				50
Unknown				3

### MEMBERSHIP BY TYPE

<u>Type</u>	<u>Number in 1991</u>	<u>Present Number</u>	<u>Difference</u>
Individual	468		
Student	69		
Emeritus	22		
Life	18		



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Honorary	6	
Sustaining Individual	6	
Sustaining Organization	1	
Library - University	29	26
Library - High School	50	50
Unknown	273	

7. The President called for a report from the Executive Director. Dr. Leven Hazelgrove did not present any additional report.

8. The President called on Dr. Nelson for a report from the Place and Date of Meeting Committee. Our meeting next year is March 24-27 at The University of Alabama at Huntsville. Subsequent years will find us at Troy University (1994), UAB (1995) and probably Tuskegee (1996).

9. The President asked for a report from the Research Committee. Dr. Tom Jandabeur presented the following:

Winners of the Research Awards, by section, were:

### Posters

Health Sciences	Kibia Meyers	Oakwood College
Biological Sciences	Susila Dorai-raj	Auburn University
Biological Sciences	Sabine Piller	UAB

### Papers

Biological Sciences	Kara Lee	UAB
Biological Sciences	Charles Bishop	UAB
Chemistry	Valarie Henry	Univ. of North Alabama
Physics	Sihon Crutcher	Tuskegee
Geology	Janet Coker	Auburn University
Social Sciences	Amy Alderman	Birmingham-Southern
Health Sciences	Linda Streit	UAB
Engineering & Computer Science	Faizal Eledath	UAB
	Hiryoung Kim	UAB
Anthropology	Rebecca Lumpkin	Univ. of South Alabama

Research grants were awarded as follows:

James Buchanan	Biological Sciences - Univ. of South Alabama
Rebecca Lumpkin	Anthropology - Univ. of South Alabama
Janet Coker	Geology - Auburn University

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J. Neil Daniell	Geology - Auburn University
Jonathan Grimes	Geology - Auburn University
R. Alan Davis	Chemistry - Auburn University
Mickie Powell	Biological Sciences - UAB
Sabine Piller	Biological Sciences - UAB
Faizal Eledath	Engineering & Computer Sciences - UAB
Nikhil Umrani	Engineering & Computer Sciences - UAB
Prakash Muthukrishnan	Engineering & Computer Sciences - UAB
Chandra Sekaran Venkatapathy	Engineering & Comp. Sciences - UAB
Li	Engineering & Computer Sciences - UAB
Hiryoung Kim	Engineering & Computer Sciences - UAB
Vivek Anumolu	Engineering & Computer Sciences - UAB

10. The President called for a report from the Nominating Committee. Dr. Prakash Sharma submitted the following:

First Vice-President	Dr. Prakash Sharma
Second Vice-President	Dr. Eugene Omasta
Treasurer	Dr. Larry Krannich
Editor	Dr. James Bradley
Counselor to the Junior Academy	Dr. B.J. Bateman
Coordinator of State Science Fairs	to be announced
Trustees:	Dr. William J. Barrett
	Mr. Roy J. Nichols
	Dr. Philip Beasley
	Mrs. Elsie Spencer

### Sections:

- II. Chemistry
  - Chairperson: Dr. Moore Asouzu, Troy State University
  - Vice-Chair: Dr. Jack DeRuitor, Auburn University
- III. Geology
  - Chairperson: Mr. Lewis S. Dean, Geological Survey of Alabama
  - Vice-Chair: Dr. David C. Kapaska-Merkel, Geological Survey of Alabama
- IV. Forestry, Geography, Conservation and Planning
  - Chairperson: Dr. Gregory Jeane - Samford University
  - Vice-Chair: Ms. Pricilla Holland - Univ. of North Alabama

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- V. Physics and Mathematics  
Chairperson: Dr. William Boardman - Birmingham-Southern  
Vice-Chair: Dr. Osker Essenwanger - Univ. of Al. at Huntsville
- VII. Science Education  
Chairperson: to be announced  
Vice-Chair: to be announced
- VIII. Social Sciences  
Chairperson: Dr. R. Hudiburg - Univ. of North Alabama  
Co-Vice-Chair: Dr. D. Baskett - Tuskegee University  
Co-Vice-Chair: Dr. Karen V. Taylor - Alabama State Univ.
- IX. Health Sciences  
Chairperson: to be announced  
Vice-Chair: to be announced
- X. Engineering and Computer Science  
Chairperson: Dr. Alan P. Sprague - UAB  
Vice-Chair: Dr. Stan Vitton - University of Alabama
11. The President called for a report from the Resolutions Committee. Dr. Linda Reed submitted the following resolutions:
- For appreciation of hospitality in hosting the 1992 meeting, Dr. Roger E. Sayers; for his efforts in meeting preparations, Dr. Jeffery Richetto; for passing officers, Dr. Ken Marion and Dr. Caroline Adams; for other positions, Dr. Eugene Omasta and Rosie McKinney; and for deceased members, all former AAS presidents, Dr. George D. Palmer, Jr., Dr. David L. DeJarnette and Dr. G.O. Spencer.
12. The President called for a report from the Scholarship Committee. Dr. Stan Jones reported the following:
- There were only four applications for the teacher education scholarship this year. An offer to one of these is pending. The Committee is also soliciting proposals for the mini-grant award of \$1000 for workshops in science education.

There being no further business, the meeting was adjourned.











## INSTRUCTIONS TO AUTHORS

**Editorial Policy:** Publication of the *Journal of the Alabama Academy of Science* is restricted to members. Membership application forms can be obtained from Dr. Larry R. Boots, Department of Obstetrics & Gynecology, University of Alabama, Birmingham, AL 35294. Subject matter should address original research in one of the discipline sections of the Academy: Biological Sciences; Chemistry; Geology; Forestry, Geography, Conservation, and Planning; Physics and Mathematics; Industry and Economics; Science Education; Social Sciences; Health Sciences; Engineering and Computer Science; and Anthropology. Timely review articles of exceptional quality and general readership interest will also be considered. Invited articles dealing with Science Activities in Alabama are occasionally published. Book reviews of Alabama authors are also solicited. Submission of an article for publication in the *Journal* implies that it has not been published previously and that it is not currently being considered for publication elsewhere.

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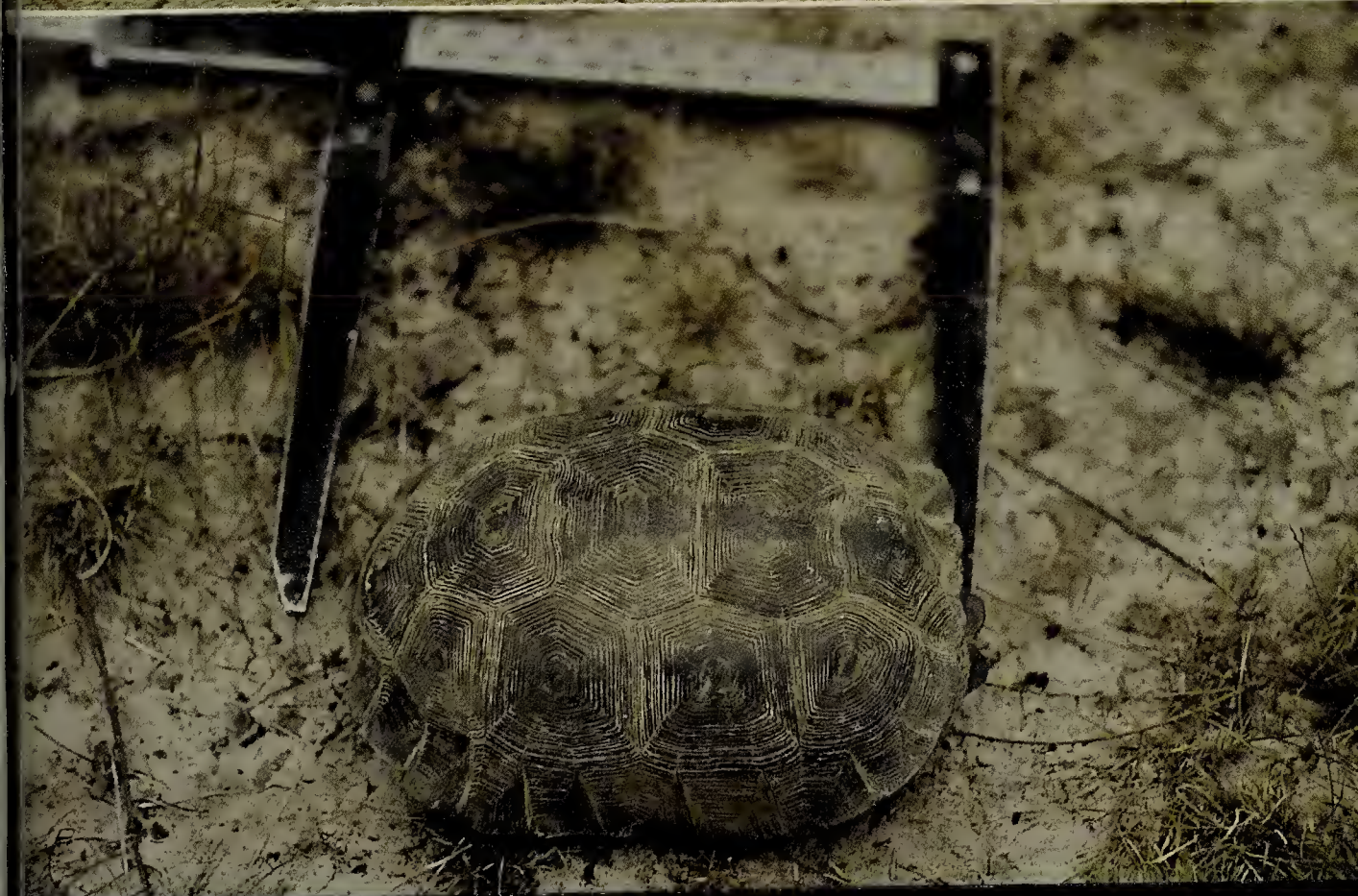
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**COVER PHOTOGRAPHS:** The burrow of a gopher tortoise (*Gopherus polyphemus*) provides shelter for numerous vertebrates and invertebrates. The burrow and tortoise shown here were found at the Dwight Harrigan Forest Resources Center (FRC), on the campus of Mobile College. John Marshall, Steve Carey, and James Buchanan report on the effects of timber harvesting on a tortoise colony located at the FRC.

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IMPACT OF TIMBER HARVESTING ON A  
COLONY OF GOPHER TORTOISES (*GOPHERUS POLYPHEMUS*)<sup>1</sup>

John E. Marshall  
*Alabama Department of Environmental Management*  
2204 Perimeter Road  
Mobile, AL 36615

Steven D. Carey  
*Department of Natural Sciences*  
*Mobile College*  
P. O. Box 13220  
Mobile, AL 36613

and

James V. Buchanan  
*Department of Biological Sciences*  
*University of South Alabama*  
Mobile, AL 36688

ABSTRACT

A colony of gopher tortoises (*Gopher polyphemus*) at Mobile College's Dwight Harrigan Forest Resources Center (FRC) was monitored before and after a timber thinning operation. Heavy equipment (skidders) collapsed 7 of 9 active burrows, 3 of which were juvenile-sized. No signs of excavation were observed at 3, 6 and 10 weeks. Five "new" active burrows were discovered 11 months after the thinning operation, none of which were juvenile sized. Possible effects on tortoises and recommendations for reducing future impacts are discussed.

INTRODUCTION

The gopher tortoise (*Gopherus polyphemus*) inhabits a variety of xeric habitats along the Southeastern Coastal Plain from South Carolina to Louisiana (Auffenberg and Franz 1982, Diemer 1986, Landers and Speake 1980). The most important and widespread of these habitats are longleaf pine (*Pinus palustris*) ecosystems, especially "sandhills" (Landers and Speake 1980, Means 1988).

<sup>1</sup>Manuscript received 18 May 1992; accepted 21 August 1992.



Tortoises have declined throughout their range, due to habitat destruction, human predation, and highway mortality (Auffenberg and Franz 1982, Diemer 1986, Landers and Buckner 1981, Lohofener and Lohmeier 1984, Mount 1976, Wright 1982). Habitat loss is an especially critical factor. The well-drained areas inhabited by tortoises are also favored for conversion to agriculture or development (Auffenberg and Franz 1982, Diemer 1986, Lohofener and Lohmeier 1984, Means 1988, Speake 1986). Certain forestry practices, such as dense pine monocultures and intensive site preparation have been considered detrimental to tortoises (Auffenberg and Franz 1982, Means 1988, Stout, et al. 1989, Tanner and Terry 1981). The absence of fire from tortoise habitats also results in the invasion of woody plants, canopy closure, and a decline in forage and nest site availability (Auffenberg and Franz 1982, Diemer 1986, Landers and Speake 1980, Means 1988).

The impacts of site preparation and range improvement activities on tortoises have been documented by other researchers (Diemer and Moler 1982, Landers and Buckner 1981, Tanner and Terry 1981). There is little information on the impacts of forest harvesting operations on tortoises. Wright (1982) discussed the impacts of intensive logging on juvenile tortoises in South Carolina, while Bryan (1991) studied the effects of a 300 acre clearcut on tortoises in Mississippi. Here, we report the effects of a timber thinning operation employing heavy equipment (i.e, skidders) on a tortoise colony.

## STUDY AREA AND METHODS

The study site was located at the Mobile College Dwight Harrigan Forestry Resource Center (FRC). This is a 66 ha tract of land, of which approximately 60% (39.6 ha) is sandhill habitat. The FRC is in central Mobile County, Alabama, about 20 km north of the city of Mobile.

Sandhill soils were composed of Troup loamy sands with 0-12 percent slopes (Hickman and Owens 1980). Vegetation was characterized by longleaf pine, turkey oak (*Quercus laevis*) laurel oak, (*Quercus laurifolia*), dogwood (*Cornus florida*), blueberries (*Vaccinium* spp.), grasses and forbs. Fire had been absent from this area for many years, and there was a dense midstory and understory of woody plants.

This study was originally initiated in March 1989 as a survey of burrows within the FRC to obtain information on the status of the tortoise colony. In August 1989, Mobile College initiated a timber thinning operation at the FRC. The thinning operation began before the researchers could adequately protect the burrows, and skidder operators were not instructed to avoid tortoise burrows.

The destruction of numerous burrows was noted after the thinning operation. The study was then expanded in an attempt to assess the impact of the skidders on the tortoises and to follow the recovery, if any, of the colony.

## Colony of Gopher Tortoises

Tortoise burrows were located before and after timber thinning by searching existing trails, clearings, and walking 7 m wide, variable length transects. Each burrow was flagged, mapped, and assigned a number in the order in which it was found. Burrow widths (BW) were measured to the nearest 0.5 cm at a depth of 25.0 cm. Burrows were classified as active, inactive, or abandoned according to the criteria of Auffenberg and Franz (1982).

### RESULTS

Twenty-two burrows were located prior to the timber thinning operation, of which 9 (40.9%) were considered active. Mean BW for all burrows was 15.75 cm (SD = 4.91, Range = 6.5 - 22.5 cm). Mean BW for active burrows was 14.67 cm (SD = 6.45, Range = 6.5 - 21.5 cm). Density was 0.55 burrows/ha.

Twelve burrows were collapsed during timber thinning. Seven of these burrows were identified as active prior to the thinning operation (Table 1), 3 of which were juvenile-sized (BW  $\leq$  10 cm). One live juvenile tortoise was observed inside B-14.

Table 1. Gopher tortoise burrows identified as active prior to timber thinning at FRC

Burrow Number	Burrow Width (cm)
B-1	19.0
B-2	20.0
* B-3	19.0
* B-6	20.0
* B-7	21.5
* B-14	6.5
* B-18	7.0
* B-21	12.0
* B-22	7.0

\*Destroyed during timber thinning

Two burrows, B-1 and B-2, were located in a small clearing that was not impacted by the skidders. Heavy winter rains in 1989-1990 filled B-1 with sand, and it was never reopened. Approximately 10 meters from B-1 was B-2, which remained active throughout this study.

Inspection of the colony at 3, 6, and 10 weeks revealed no signs of excavation. In July 1990, 5 "new" active burrows were found at the FRC (Table 2). One of these was located at the B-6 site. No juvenile-sized burrows were discovered.

Table 2. Active tortoise burrows discovered after timber thinning at the FRC

Burrow Number	Burrow Width
* B-2	20.0
** B-6	21.0
B-23	13.0
B-24	19.5
B-25	18.5
B-26	15.5
*not destroyed during timber thinning operation	
**reopened after being destroyed by timber thinning operation	

Mean width for the active burrows found after timber thinning was 17.5 cm (SD = 3.22, Range = 13.0-21.0 cm). The width of active burrows found before and after the thinning operation was not significantly different ( $t = 0.98$ ,  $df = 13$ ,  $P = 0.05$ ). Density was 0.40 burrows/ha.

## DISCUSSION

The thinning of timber at the FRC obviously opened the canopy and undoubtedly improved tortoise habitat. The skidders, however, had a direct negative impact on tortoises by destroying burrows and possibly some animals. Although the true impact of the skidders on tortoises could not be assessed in this study, several possibilities exist.



## Colony of Gopher Tortoises

Other researchers have documented the destruction of tortoise burrows by site preparation activities (Diemer and Moler 1982, Landers and Buchner 1981), in which tortoises later dug out. Diemer and Moler (1982) reported that 3 radio instrumented tortoises later dug out 8 weeks after their burrows were collapsed. During the same 8 week period, 5 other burrows considered active prior to site preparation showed signs of tortoise emergence. Two of these burrows were reopened and maintained.

Landers and Buckner (1981) found that 11 tortoises buried by double chopping dug out within 3 weeks. After emerging, 4 tortoises remained in the area of the site preparations, 4 moved to the edge of the clearing, and three left the area entirely. None of these animals reopened and maintained their previous burrows. Tanner and Terry (1981) also found that none of the burrows destroyed during roller chopping and web plowing in Florida was reopened by tortoises.

At the FRC, the long period (11 months) between the thinning operation and the discovery of new active burrows would indicate that tortoises either did not dig out or emerged and left the area. Tortoises that do dig out of collapsed burrows often leave little or no sign of emergence (Diemer and Moler 1982, Landers and Buckner 1981). It is quite possible that some of the tortoises that emerged, moved out of the FRC to adjacent undisturbed habitat, and returned the following year.

Because tortoises often occupy more than 1 burrow (Marshall 1987, McRae, et al. 1981), the number of active burrows destroyed was not necessarily equal to the number of tortoises affected. Using a correction factor of 0.6 times the number of active burrows (Spillers and Speake 1989), there were probably 5-6 tortoises affected by the timber thinning operation. The 5 new burrows discovered in July 1990 may have been constructed by previous residents. Burrows 3 and 21, discovered prior to the thinning operation (Table 1), were similar in size to burrows 23 and 24, respectively, which were constructed after thinning (Table 2). These burrows could have been reopened by resident tortoises. The other post-thinning burrows were of sufficiently different widths from pre-thinning burrows to have been constructed by new tortoises.

The only burrow that was opened and maintained after its collapse was B-6. It could not be determined whether this was by the original occupant or an immigrant from outside the FRC. The BW measurements of this burrow before and after collapse differed by only 1 cm (Tables 1 and 2), so the original occupant may have returned.

Although direct evidence is lacking, the timber thinning operation may have caused the death of the juvenile tortoises, thus explaining the absence of juvenile-sized burrows after the operation. Landers and Buckner (1981) reported infrequent juvenile mortality from heavy equipment, whereas Wright (1982) believed that timber thinning resulted in high juvenile mortality in South Carolina. The juvenile tortoises

may have dug out, left the FRC area, and simply not returned. Diemer and Moler (1982), however, found hatchling tortoises on their study area after site preparation and believed them to be residents because of the limited movements of young tortoises (McRae, et al. 1981).

Juvenile tortoises may have remained within the FRC, and either constructed new burrows in inconspicuous places or moved into undamaged adult-sized burrows. The co-occupancy of immature tortoises with adults has been suggested by other researchers (Alford 1980, Douglas 1978). Burrows 1 and 2, which were not destroyed, may have provided refuges for these juveniles.

Bryan (1991) found that tortoises remained on his study site after clearcutting, and also reported that juveniles survived the logging operation. This cut, however, employed strict rules, such as a 3 m buffer zone around each burrow to protect it from heavy equipment. No such special protection was provided for during the operation at the FRC. As a result, it is probable that the juveniles on site were crushed by the skidders. The ultimate fate of the tortoises that occupied the destroyed burrows, however, is unknown.

## CONCLUSIONS

The initial impacts of the thinning operation on the tortoise colony were obviously negative. Besides the destruction of active burrows, it is possible that juvenile tortoises and incubating eggs were crushed by the skidders. There may also have been some detrimental effects on many of the other species that utilize tortoise burrows for shelter (Jackson and Milstrey 1989).

The negative impacts on adult tortoises and their burrows appear to have been short-lived. The new burrows were found within 1 year of the thinning operation, and would indicate that tortoises were responding to the improved habitat. A burrow census conducted in July 1992, found 15 active burrows. All burrows have been marked and efforts have been made to avoid impacting them during future activities at the FRC. The use of prescribed burning to control shrub and deciduous tree invasion, instead of mechanical means, would also reduce the impact of heavy equipment on soil disturbance and destruction of resident fauna and flora.

## LITERATURE CITED

- Alford, R. A. 1980. Population structure of *Gopherus polyphemus* in northern Florida. J. Herp. 14:177-182.

## Colony of Gopher Tortoises

- Auffenberg, W. and R. Franz. 1982. The status and distribution of the gopher tortoise (*Gopherus polyphemus*) in North American tortoises: conservation and ecology. R. B. Bury, ed. U. S. Fish and Wildl. Serv. Wildl. Research Report 12:95-126.
- Bryan, T. Effects of Black Creek seed orchard establishment on a population of gopher tortoises (*Gopherus polyphemus* Daudin): in southeastern Mississippi. M. S. Thesis, Auburn University, Auburn, AL 52 pp.
- Diemer, J. E. 1986. The ecology and management of the gopher tortoise in the southeastern United States. *Herpetologica*. 42(1):125-133.
- Diemer, J. E. and P. E. Moler. 1982. Gopher tortoise response to site preparation in northern Florida. Ann. Conference S. E. Assoc. Fish and Wildl. Agencies.
- Douglass, J. F. 1978. Refugia of juvenile gopher tortoises *Gopherus polyphemus*. *J. Herp.* 12(3):413-415.
- Hickman, G. H. and C. Owens. 1980. Soil survey of Mobile County, Alabama. Soil Conservation Serv., U. S. Dept. of Agriculture. 134 pp.
- Jackson, D. R. and E. G. Milstrey. 1989. The fauna of gopher tortoise burrows. Proc. gopher tortoise relocation symposium. J. E. Diemer, D. R. Jackson, J. L. Landers, J. N. Layne, D. A. Woods, eds. Nongame Wildl. Program Tech. Report 5:86-88.
- Landers, J. L. and J. L. Buckner. 1981. The gopher tortoise: effects of forest management and critical aspects of its ecology. Southlands Experimental Forest Tech Note 56.7
- Landers, J. L. and D. W. Speake. 1980. Management needs of sandhill reptiles in southern Georgia. Proc. Ann. Conference S. E. Assoc. Fish and Wildl. Agencies. 34:515-529.
- Lohofener, R. and L. Lohmeier. 1984. The status of (*Gopherus polyphemus*) Testudines, Testudinidae west of the Tombigbee and Mobile Rivers. Report to U.S. Fish and Wildl. Serv. in support of petition to list this population under the Endangered Species Act of 1973. 116 pp.
- Marshall, J. C. 1987. The effects of nest predation on hatching success in gopher tortoises (*Gopher polyphemus*) Daudin 1802. M.S. Thesis, University of South Alabama, Mobile AL 77 p.
- McRae, W. A., J. L. Landers, and J. A. Garner. 1981. Movement patterns and home range of the gopher tortoise. *The American Midl. Naturalist*, 106(1):165-179.



- Means, D. B. 1988. Management recommendations for the gopher tortoise in longleaf pine ecosystems. Proc. Ann. Meeting of the Gopher Tortoise Council 6:44-56.
- Mount, R. H. 1976. Amphibians and reptiles *in* Endangered and threatened plants and animals of Alabama. Bull. Alabama Mus. Nat. Hist. 2:66-79.
- Speake, D. W. 1986. Gopher tortoise (*Gopherus polyphemus* Daudin), Testudinidae, Testudines, *in* Vertebrate animals of Alabama in need of special attention. R. H. Mount, ed. Al. Agri. Experiment Station. Auburn, AL 41-42.
- Spillers, D. M. and D. W. Speake. 1989. A survey method for measuring gopher tortoise density and habitat distribution *in* Management of Reptiles, amphibians, and small mammals in North America. Gen. Tech. Report RM-166, U.S. Dept. Agri. For. Serv. Pp. 199-204.
- Stout, J. J., D. R. Richardson, and R. E. Roberts. 1989. Response of resident and relocated gopher tortoises to a prescribed burn in a sand pine scrub community *in* Proc. gopher tortoise relocation symposium. J. E. Diemer, D. R. Jackson, J. L. Landers, J. N. Layne, D. A. Woods, eds. Nongame Wild. Program Tech. Report 5:84-85.
- Tanner, G. W. and W. S. Terry. 1981. Effect of roller chopping and web plowing on gopher tortoise burrows in southern Florida. Proc. Ann. Meeting of the Gopher Tortoise Council 2:66-73.
- Wright, S. 1982. The distribution and population biology of the gopher tortoise (*Gopherus polyphemus*) in South Carolina. M. S. Thesis, Clemson University, Clemson, S. C. 77 pp.

## SURVEY OF COMPUTER USE BY UNDERGRADUATE PROGRAMS IN PSYCHOLOGY IN SOUTHEASTERN STATES<sup>1</sup>

Richard A. Hudiburg and Bruce Sides  
*Department of Psychology*  
*University of North Alabama*  
*Florence, AL 35632-0001*

### INTRODUCTION

The use of computers in the teaching of psychology has developed rapidly over the past two decades. Beins (1989) noted that early instructional use of computers was for simple drill-and-practice activities, utilizing mainframe computers, while today computers are used increasingly for teaching psychological concepts and techniques. Increased microcomputers sophistication and decreased prices of hardware and software have made computers more available for college budgets.

There have been several surveys of microcomputer use in psychology departments. Pavel (1981) surveyed the use of computers in psychology laboratories. Castellan (1982) surveyed the instructional applications of both microcomputers and mainframe computers in psychology. Carpenter (1986) surveyed microcomputers instructional use in small psychology departments with school enrollments between 500 and 5000. Stoloff and Couch (1987) conducted a survey of computer use in 29 of 36 undergraduate psychology departments of four-year colleges in Virginia. Lehman (1988) investigated the computer programming languages used by psychologists.

There have been two recent studies utilizing samples national in scope. Couch and Stoloff (1989) surveyed 250 psychology departments, which offered a major in psychology, with respect to microcomputer use by faculty. Their survey addressed questions concerning the nature of faculty use, type of hardware, type of software, instructional use, and value of microcomputers in specific courses offered in the major. Anderson and Hornby (1990) conducted a survey of users of COMPSYCH, a computer information bulletin board, relating to use of computers in psychology. Respondents to their survey were from academic institutions in the United States, Canada, and other foreign countries.

Each of these surveys sought a variety of information using different sample strategies. The national surveys have included departments of psychology which offer

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training at the doctoral level. The availability of resources at research institutions is generally greater than that at primarily undergraduate institutions or at institutions with small masters graduate programs in psychology.

There is a need to survey computer use in psychology programs on a regional basis. Regional survey results can provide a better standard for comparison of institutions in an area. This survey focused on the use of computers in undergraduate psychology programs in five southeastern states.

## METHODOLOGY

A survey sample included 100 colleges and universities which: 1) offered an undergraduate major in psychology (*College Blue Book*, 1989), 2) had a mission primarily undergraduate in nature (non-doctoral), and 3) were located in one of five southeastern states (number in each state in parentheses): Alabama (18), Florida (20), Georgia (24), Mississippi (10), or Tennessee (27).

A survey questionnaire was sent to the chairperson or a designated faculty member in each department. The survey questionnaire requested information concerning:

- 1) demographic characteristics of the departments,
- 2) computer use by faculty, staff, and students,
- 3) computer use in the psychology program curriculum,
- 4) department availability of computer hardware,
- 5) a list of most commonly used computer software.

The questionnaires were mailed during October 1990. Two months after the questionnaires were mailed, a second questionnaire was mailed to those not responding. No other efforts were made after the second mailing to solicit survey information.

## RESULTS

Completed surveys were collected from 56 of the 100 departments (56% return rate). The return rates by states were Alabama (67%), Florida (60%), Georgia (67%), Mississippi (50%), and Tennessee (33%). The psychology programs varied in size from 15 to 400 majors (Median = 90). The number of full-time faculty varied from 1 to 15 (Median = 4), with the most typical size being 4 or fewer faculty members. The number of part-time faculty ranged from 0 to 8. Typically a program had no part-time faculty.



## Computer Use

### *Computer Use*

The surveyed programs indicated that 66.2% of the faculty actively used computers for instruction and research. There was a nonsignificant correlation ( $r(51) = .02$ ) between reported faculty use and number of full-time faculty. This result was consistent with that found by Couch and Stoloff (1989) and indicated that use of microcomputers was unrelated to the number of faculty. Table 1 shows the percentage of programs reporting use for various purposes by faculty, staff, and students. For all three groups, word processing was the most popular reported

Table 1. Percent Surveyed Programs Reporting Various Uses of Computers By Faculty, Staff and Students

	Faculty	Staff	Students
Word Processing	91.1	69.6	71.4
Statistics	87.5	5.4	71.4
Test Generation	75.0	32.1	0.0
Demonstrations	55.4	5.4	21.4
Lab Component	58.9	7.1	48.2
Simulation/Tutorials	50.0	1.8	44.6
Data-base management	41.1	19.6	10.7
Spreadsheets	33.9	17.9	7.1
Telecommunications	26.8	1.8	1.8

computer use. These data were comparable to the results reported by Stoloff and Couch (1987) for Virginia undergraduate psychology programs. The current survey showed higher percentages of use in most use categories as compared to Stoloff and Couch (1987).

### *Curriculum Uses*

Computer literacy requirements were met in various ways. Psychology programs having required computer literacy composed 50% of the surveyed schools, 30.4% recommended computer literacy, while 19.6% had no requirement or recommendation of computer literacy. The requirement of computer literacy could

be met by taking a computer course in 58.3% of the psychology programs. In 38.9% of the psychology programs the computer literacy requirement was met in a psychology course. There were many types of use of computers in psychology program instruction.

Table 2 shows that microcomputers were most often used in research methods (75%) and statistics (71.4%) courses and least often in personality courses (1.8%). Statistics courses were most often reported requiring the use of microcomputers

Table 2. Computer Use and Instructional Value of Microcomputers in Psychology courses (value rating range from 0 - no value to 5 - high value)

	% Using <sup>a</sup>	% Requiring Use	Mean Value Rating
Research Methods	75.0	37.5	4.23
Statistics	71.4	41.1	4.36
Experimental	51.8	26.8	4.23
Introductory	37.5	10.7	3.59
Learning	32.1	14.3	3.89
Independent Study	30.4	12.5	4.65
Cognitive	25.0	12.5	3.93
Psychological Testing	19.6	10.7	3.92
Physiological	16.1	1.8	3.45
Sensation/Perception	12.5	5.4	3.56
Educational	8.9	1.8	2.86
Social	7.1	0.0	2.50
Abnormal	5.4	0.0	3.00
History & Systems	3.6	1.8	3.00
Developmental	3.6	0.0	2.33
Personality	1.8	0.0	2.33

<sup>a</sup>Percentage of departments reporting some microcomputer use in a specific course.

## Computer Use

(41.1%). The surveyed programs were asked to rate the instructional value of microcomputers in each course on a 5-point scale ranging from *no value* (1) to *high value* (5). Microcomputers were most valued, based on the ratings in Table 2, in courses requiring the manipulation of numerical information (e.g., independent study, statistics, research methods, and experimental activity) and least valued in courses requiring no use of numerical data (e.g., developmental, personality, educational, and social). These results were similar to those reported by Couch and Stoloff (1989).

### *Computer Facilities and Equipment*

The surveyed programs reported that 32.1% had psychology computer labs, 21.4% had shared computer labs, and 46.4% had school wide computer labs. Table 3 shows the types of microcomputers and other computer hardware reported by the surveyed programs. The IBM PC/PC compatible was the most frequently reported

Table 3. Types of computer equipment in surveyed (N = 56) psychology programs

Microcomputers	% Having	Mean Number	Range
IBM PC/PC compatibles	67.9	5.4	1 - 18
Apple II	42.9	3.1	1 - 18
MacIntosh	19.6	2.7	1 - 5
Others	12.5	2.7	1 - 8
Other computer hardware	% Having	Most Frequent Type (Number)	
Mainframe	39.3	IBM (4)	
Minicomputer	60.7	VAX (10)	
Networks	39.3	Bitnet (3)	
Laboratory Interface	16.1		
Laser printers	53.6		
Supercomputer access	14.3		



system, followed by Apple II, then MacIntosh. The IBM PC/PC compatibles accounted for 60.8% ( $N = 200$ ) of the microcomputers, the Apple II family 22.5% ( $N = 74$ ) and MacIntosh 10.0% ( $N = 33$ ). The current survey confirms the trend towards increased use of IBM PC/PC compatible equipment and lower use of Apple II equipment as was noted by Anderson and Hornby (1990). In terms of other computer hardware, Table 3 showed that a majority of the schools had minicomputers (60.7%) and laser printers (53.6%).

The number of microcomputers in use in a psychology program was not significantly correlated with the number of full-time faculty ( $r(54) = .32$ ). The number of microcomputers available was not significantly correlated with the number of majors ( $r(51) = .22$ ). These results differed from those found by Stolloff and Couch (1987), who found significant correlations. The current results indicated that program size had no relationship to the number of microcomputers in use.

There was a large variety of software reported in use by the surveyed schools. The most popular computer software used by the surveyed programs are shown in Table 4. The results indicated that Word Perfect was the most frequently used of 17 different word processors used, SPSS was the most often used of some 25 statistical

Table 4. Most frequently reported computer software packages used in surveyed psychology programs ( $N = 56$ )

Software Type	% of Programs Reporting Use
<u>Word-processing:</u>	
Word Perfect	57.1
Word Star	19.6
Appleworks	17.9
Microsoft Word	8.9
<u>Statistical Packages:</u>	
SPSS	44.6
SAS	14.3
MYSTAT	8.9
SYSTAT	7.1
Minitab	7.1
<u>Data-base management:</u>	
Dbase	25.0
Appleworks	7.1

## Computer Use

### Spreadsheets:

Lotus 123	23.2
Quattro	10.7
Appleworks	8.9

### Simulations and tutorials:

CONDUIT programs	21.4
PSY SIMULATION	5.4

### Graphics:

Harvard Graphics	8.9
Graph-in-the-box	3.6
Word Perfect Graphics	3.6
First Choice	3.6

---

packages, Dbase was the most often used of the 6 different data-base programs, Lotus 123 was the most frequently used of 7 distinct spreadsheet programs, the CONDUIT series of programs was the most frequently used of some 23 simulations/tutorials, and Harvard Graphics was the most frequently used of 10 separate graphics programs. Most of the programs were developed for the microcomputer, with the exception of the two most frequently reported statistical packages (SPSS and SAS).

A majority (77.8%) of the surveyed psychology programs reported that their schools assisted faculty, staff, and students in obtaining computers for instructional and research use. The surveyed programs reported annual department budgets for purchasing computer hardware/software ranging from \$0 to \$40,000 (Median = \$2250). In terms of the adequacy to which their computers needs were met, 26.8% of the programs reported they were very adequately met, 25.7% responded that their needs were moderately met, 23.2% reported their computer needs were barely met, while 14.3% reported their computer needs were not being met.

## DISCUSSION

The current study has revealed many similarities to previous surveys of computer use in psychology programs. Microcomputers were generally available in psychology programs without regard to the size of the program. There was a high level of computer use by faculty members, which was consistent with the survey of Couch and Stoloff (1989). The most frequent use of computers by faculty, staff, and students was word processing. This result was consistent with the results of Stoloff and Couch (1987) and showed an increasing trend towards use of word processing as compared to the earlier surveys of Castellan (1982) and Carpenter (1986).

Most programs surveyed required or recommend computer literacy which was usually met by taking a computer course. Computers were used most often in courses requiring data analyses (e.g., research methods, statistics, and experimental). This result was consistent with that found in surveys by Carpenter (1986), Couch and Stoloff (1989), and Anderson and Hornby (1990).

Anderson and Hornby (1990) reported the trend towards increased use of IBM PC/PC compatibles hardware in psychology programs. The current survey concurs with this result. This increased use of IBM PC/PC compatibles was due to the wider availability of psychology software written for these systems and to the decreased cost of computer hardware (Beins, 1989).

The surveyed psychology programs generally thought that their computer needs were *not* being met. There were moneys available in the programs to purchase computer hardware and software and there was assistance by the institutions for acquiring computers by faculty, staff, and students.

The current survey was regional in nature. it showed that the surveyed psychology programs in the southeastern states were, compared to national surveys, on par with programs in other parts of the country.

#### ACKNOWLEDGEMENTS

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#### LITERATURE CITED

- Anderson, M. & Hornby, P. (1990). Computer use in psychology instruction. *Behavior Research Methods, Instrument, & Computers*, 22, 194-199.
- Beins, B.C. (1989). A survey of computer use reported in *Teaching of Psychology*: 1974-1988. *Teaching of Psychology*, 16, 143-145.
- Carpenter, D.L. (1986). A survey of microcomputer use in small psychology departments. *Behavior Research Methods, Instruments, & Computers*, 18, 155-156.



## Computer Use

- Castellan, N.J., Jr. (1982). Computers in psychology: A survey of instrumental applications. *Behavior Research Methods, Instruments, & Computers*, 14, 198-202.
- College Blue Book*. (1989). New York: Macmillian.
- Couch, J.V. & Stoloff, M.L. (1989). A national survey of microcomputer use by academic psychologists. *Teaching of Psychology*, 16, 145-147.
- Lehman, R.S. (1988). The languages we use. *Behavior Research Methods, Instruments, & Computers*, 20, 136-242.
- Pavel, M. (1981). Results of a preliminary survey of computer users in psychological laboratories. *Behavior Research Methods, Instruments, & Computers*, 13, 272-275.
- Stoloff, M.L. & Couch, J.V. (1987). A survey of computer use by undergraduate psychology departments in Virginia. *Teaching of Psychology*, 14, 92-94.

## STRONGLY NIL IDEALS<sup>1</sup>

Haghdad Memaoui  
*Department of Mathematics*  
*Tuskegee University*  
*Tuskegee, AL 36088*

### ABSTRACT

Nil and nilpotent ideals of a ring are well known and they have been used widely in the study of rings. We recall that an ideal  $I$  of a ring is said to be a nilpotent ideal if  $I^n=0$  for some positive integer  $n$ ; it is called a nil ideal if each element  $a$  of  $I$  is nilpotent in the sense that  $a^n=0$  for some positive integer  $n$ .

The purpose of this article is to define a new class of ideals which lies between the classes of nilpotent and nil ideals. All rings under consideration are associative rings with identity.

Lambek [2:55] defines an element  $a$  of a ring  $R$  to be strongly nilpotent provided every sequence  $a_0, a_1, a_2, \dots$ , such that

$$a_0=a, a_{n+1} \in a_n R a_n$$

is ultimately zero. It is clear that a strongly nilpotent element is nilpotent. The

converse, however, is not always true as the element  $\begin{bmatrix} 0 & 1 \\ 0 & 0 \end{bmatrix}$  of the ring of all  $2 \times 2$  rational matrices is a nilpotent element that is not strongly nilpotent. But in a commutative ring every nilpotent element is strongly nilpotent [2:56].

We shall now make the following definition.

*Definition:* We call an ideal  $I$  of a ring a strongly nil ideal if every element of  $I$  is strongly nilpotent.

It follows from this definition that a strongly nil ideal is a nil ideal. In the next theorem we prove that the class of nilpotent ideals of a ring is contained in the class of its strongly nil ideals.

*Theorem:* A nilpotent ideal is strongly nil.

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## Strongly Nil Ideals

Proof. Suppose  $I$  is a nilpotent ideal of a ring  $R$ , and let  $a$  be an element of  $I$ . Consider the sequence  $a_0, a_1, a_2, \dots$ , such that

$$a_0 = a, a_{n+1} \in_n R a_n$$

We note that  $a_0 = a \in I$ ,  $a_1 = a_0 r_1 a_0 = a r_1 a \in I^2$ ,  $a_2 = a_1 r_2 a_1 = a r_1 a r_2 a r_1 a \in I^4$ ,  $\dots$ ,  $a_n \in I^2$ . Since  $I$  is nilpotent, this sequence must be ultimately zero. Therefore,  $I$  is a strongly nil ideal.

As we will see, there are nil ideals that are not strongly nil and strongly nil ideals that are not nilpotent. However, in a commutative ring the notions of strongly nil ideal and nil ideal are the same and in a right Noetherian ring all of these three classes of ideals are the same [2:70].

One consequence of this definition is that the prime radical of a ring is a strongly nil ideal. In fact, the prime radical is the set of all strongly nilpotent elements of the ring [2:56]. Hence, an ideal of a ring is a strongly nil ideal if and only if it is contained in the prime radical of the ring.

Next, we use an example of Baer's to show that nil does not imply strongly nil.

Baer [1:540] has constructed an example of a ring  $R$  whose lower radical is zero and which contains a nonzero two-sided nil ideal  $T$ . If  $T$  is a strongly nil ideal, then it must be a subset of the prime radical of  $R$  [2:56]. This forces  $T$  to be zero, which is a contradiction. Therefore,  $T$  is an example of a nil ideal that is not strongly nil.

We shall now exhibit a strongly nil ideal that is not nilpotent.

*Example:* Let  $S$  denote the ring of all infinite by infinite matrices of the following form over  $\mathbb{Z}_2$

$$\begin{bmatrix} 0 & * & * & \dots & * & * & 0 & 0 & \dots \\ 0 & 0 & * & \dots & * & * & 0 & 0 & \dots \\ 0 & 0 & 0 & \dots & * & * & 0 & 0 & \dots \\ \vdots & & & & & & & & \\ 0 & 0 & 0 & \dots & 0 & * & 0 & 0 & \dots \\ 0 & 0 & 0 & \dots & 0 & 0 & 0 & 0 & \dots \\ \hline & & & & n \times n & & & & \\ 0 & 0 & 0 & \dots & 0 & 0 & 0 & 0 & \dots \\ 0 & 0 & 0 & \dots & 0 & 0 & 0 & 0 & \dots \\ \vdots & & & & & & & & \end{bmatrix}$$



where all of its entries are zero except possibly the entries above the main diagonal of the  $n \times n$  upper left block matrix, with  $n$  an arbitrary positive integer, and asterisks indicating the possible nonzero entries. We note that the border of zeros in these matrices has a two-fold effect: closure under multiplication and nilpotency. We adjoin an identity to  $S$  by imbedding it in the ring  $R = \mathbb{Z}_2 \times S$  in which addition is defined componentwise and multiplication is defined by

$$(i,a) \cdot (j,b) = (ij, ab+ib+ja).$$

Under these operations  $R$  is an associative ring with identity  $(1,0)$ .  $S$ , which is isomorphic to  $(0) \times S$ , is an ideal of  $R$ . We claim that  $S$  is a strongly nil ideal which is not nilpotent. First, we note that if  $a$  is an element of  $S$  whose upper left block matrix is a  $k \times k$  matrix and if  $a$  occurs at least  $k$  times in a product  $a_1 a_2 \dots a_m$ , of the elements of  $S$ , then such a product is zero. Next, let  $a \in S$  and consider the sequence  $a_0, a_1, a_2, \dots$ , such that  $a_0 = a$ ,  $a_{n+1} \in a_n R a_n$ . It can be verified that  $a_k$ , the  $k$ th term of this sequence, is a finite sum of finite products of elements of  $S$ , such that in each product  $a$  occurs  $2^k$  times. Therefore, by choosing  $k$  large enough  $a_k$  becomes zero. This implies that  $a$  is a strongly nil ideal. However, for any positive integer  $i$ , if we define  $a$  to be the element of  $S$  whose upper left block matrix is the  $(i+1) \times (i+1)$  matrix with 1's as the entries above its main diagonal, then  $a^i \neq 0$ . Hence,  $S$  is not a nilpotent ideal.

Since a strongly nil ideal is a nil ideal,  $S$  is also an example of a nil ideal that is not nilpotent.

## REFERENCES

1. R. Baer, Radical Ideals, *Am. J. Math.* 65 (1943), 537-568.
2. J. Lambek, *Lectures on Rings and Modules*, Chelsea Publishing Co., New York, 1986.









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**EDITOR'S NOTE:** The following two abstracts of research papers presented at the 1992 annual meeting of the *Alabama Academy of Science* were inadvertently omitted from the April issue of the *Journal*. I apologize to the authors for this oversight.

Jim Bradley, Editor  
*Journal of Alabama  
Academy of Science*

## ABSTRACTS

**VORONOI APPROACH FOR CHECKING PAD DIAMETER IN PRINTED CIRCUIT BOARDS.** Hiryoung Kim and Alan Sprague, Dept. of Computer and Information Sciences, University of Alabama at Birmingham, Birmingham, AL 35294.

One of the checks that must be performed during manufacture of a printed circuit board is to test that every pad is sufficiently large. The standard method of accomplishing this uses erosion, which, however, is computationally intensive. We present an alternative approach, which uses the Voronoi diagram as its central element. To make the Voronoi approach efficient, we perform a preprocessing step which thins the data that the Voronoi diagram is based on.

**PERCEPTIONS OF RESIDENT PREPARATION FOR PRACTICE MANAGEMENT.** Pat Norton, George Tulli, and MinQi Wang, The University of Alabama School of Medicine--Tuscaloosa Program, Tuscaloosa, AL 35487.

Following a review of literature in practice management, a survey was developed in order to determine perceptions of practicing physicians regarding the importance of 35 items in running a successful practice. They were also asked to rate how well their medical education had prepared them to deal with these items. The survey was mailed out to the last 5 years' graduates (n=85) of the University of Alabama School of Medicine's Family Practice Residency Program, Tuscaloosa. A 57% response rate was attained. Thirty-three of the 35 items were rated as important or very important to a successful practice by more than 50% of the doctors. Of greatest importance were topics dealing with billing, fee structure, and third-party payers. Over half the doctors surveyed felt unprepared or very unprepared to deal with these topics. Also listed as important or very important by at least 86% of the doctors were issues in personnel management, with, again, over half the doctors feeling unprepared or very unprepared in this area. The responses to these surveys are being incorporated into a new, more structured family practice management curriculum.

This study was supported by grant number 1-D15-PE14325-01 from the Department of Health and Human Services.

Jack DeRuiter  
*Department of Pharmacal Sciences*  
*School of Pharmacy*  
*Auburn University, AL 36849*

During the 69th Annual Meeting of the Alabama Academy of Science in Tuscaloosa, Alabama, the Chemistry Section of the Academy held a symposium on Drugs of Abuse. A number of scientists from Alabama were invited to present papers describing their research with those drugs most commonly abused in the United States today. The drugs discussed included cocaine, amphetamines, hallucinogens (LSD, mescaline), MDMA ("Ecstasy"), opiates (morphine, heroin) and anabolic steroids and the presentations covered a wide range of topics including the classification and effects of drugs of abuse, methods by which they are prepared in clandestine laboratories and formulated for distribution, and procedures to analyze and determine the composition of street drug samples. While the symposium subject matter was directed primarily toward chemists, the broad scope of the presentations and the significance of the substance abuse problem in this state and the nation prompted publication of the symposium presentations in the *Journal*. This issue of the *Journal* contains the symposium papers dealing with cocaine, analgesic drugs and the anabolic steroids. Other papers discussing the amphetamine and "Ecstasy" drugs will be presented in subsequent issues. I would like to thank my coauthors for the timely preparation of the manuscripts for publication.



## ANABOLIC STEROIDS: ABUSE AND CLANDESTINE PRODUCTS<sup>a</sup>

F. Taylor Noggle, Jr.  
*Alabama Department of Forensic Sciences*  
*P. O. Box 3510*  
*Auburn, AL 36830*

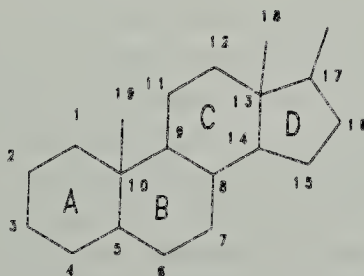
and

Jack DeRuiter  
C. Randall Clark  
*Department of Pharmacal Sciences*  
*School of Pharmacy*  
*Auburn University, AL 36849*

### INTRODUCTION

Anabolic steroids are derivatives of testosterone, the male hormone secreted by the testes. The physiological actions of testosterone are characterized as either androgenic or anabolic. Androgenic activity involves the development and maintenance of masculine traits and the male reproductive system, while anabolic activity involves a general promotion of tissue growth [1]. Numerous testosterone derivatives have been developed in an attempt to separate androgenic and anabolic properties. Those analogues with a relatively high ratio of anabolic to androgenic activity are collectively referred to as the anabolic steroids [2].

All of the steroid structures contain the characteristic tetracyclic nucleus termed the cyclopentanoperhydrophenanthrene ring system - a five membered cyclopentane ring fused to a fully reduced phenanthrene ring system. The steroid ring system is numbered by position and the rings designated by letters as shown below.



### STEROID RING SYSTEM

<sup>a</sup>Manuscript received 11 September 1992; accepted 1 October 1992.

Including veterinary products, it is estimated that there are as many as 80 anabolic-androgenic steroids marketed worldwide [3]. The abuse of at least 13 steroids has been documented in the literature, and anabolic steroid use has increased steadily over the past decade [3-7]. It has been established that athletes competing in a variety of sports from high school [7] to the professional level [8] have used anabolic steroids to increase muscle development and strength, decrease healing time following injury, diminish fatigue and increase aggressiveness [4,5,8-10]. Furthermore, the growing interest in personal fitness and appearance has been accompanied by an increase in the casual use of steroids [11] despite enhanced awareness of the dangers and intensified efforts to limit steroid availability.

The adverse effects associated with anabolic steroid use are dependent on the agent, dose, and duration of use [6]. Typically, these steroids significantly alter endocrine function, producing testicular atrophy and decreased spermatogenesis in males [10, 12] and menstrual irregularities and masculinization in females [13]. The anabolic steroids also adversely effect the cardiovascular system causing sodium and water retention and increasing LDL cholesterol levels [10, 14]. Perhaps the most serious effects associated with steroid use are disorders of the liver including peliosis hepatitis and liver tumors (hepatomas) [12]. The anabolic steroids also alter behavior, producing effects ranging from increased aggressiveness and irritability to mania and psychosis [10, 13, 15].

The continuing and increasing abuse of anabolic steroids, as well as adverse reactions associated with their use, has resulted in attempts to control and limit steroid use. The FDA has eliminated the legal distribution of products containing methandrostenolone and methandriol by declaring these agents to be unapproved new drugs [16]. Also several states have placed anabolic steroids on their controlled substances lists [17]. The use of these steroids at the amateur sports level has been banned by the International Olympic Committee and the National Collegiate Athletic Association (NCAA) [18]. Finally, effective February 27, 1991, the Department of Justice placed anabolic steroids into Schedule III of the Controlled Substances Act (21 U.S.C. 801, et. seq.) and provided a definition of anabolic steroids.

The legislative control of anabolic steroids along with the apparent increase in demand for these drugs has led to a growth in the clandestine market for steroid dosage forms [11, 19]. Also as the clandestine market grows, it is reasonable to anticipate that more "counterfeit" steroid dosage forms will be encountered. For these reasons, it is important to develop efficient and accurate analytical methods for the detection of anabolic steroids in clandestine samples. In this paper we report several spectroscopic and chromatographic techniques which may be employed for specific identification of anabolic steroids. Anabolic steroid products available are subclassified as ester derivatives or non-esters. The analytical profiles of a number of the commonly abused steroid esters and non-esters are described in this report.

## Anabolic Steroids

### EXPERIMENTAL

*General.* The steroid standards used in this study were obtained in pure form from their respective manufacturers. Clandestine samples were submitted to the Alabama Department of Forensic Sciences for analysis. All other chemicals were of reagent-grade quality and were used without additional purification. HPLC-grade methanol was obtained from Fisher Scientific and the water used in the HPLC mobile phases was double distilled.

*Instrumentation.* The liquid chromatograph consisted of a Laboratory Data Control Constametric 3000 pump, 3100 Spectromonitor UV detector operated at 240 nm or a Waters Associates Model 440 UV detector with dual wavelength accessory operated at 254 and 280 nm. UV spectra were recorded on a Shimadzu UV 265 spectrophotometer. The electron impact mass spectra were obtained using a Hewlett-Packard 5970B mass selective detector. The ionization voltage was 70eV and the source temperature was 220° C. The individual samples were dissolved in methanol (1 mg/mL) and 0.5  $\mu$ L introduced into the mass spectrometer via a gas chromatograph equipped with a 12.5 m x 0.20 mm i.d. fused silica column with a 0.33  $\mu$  film thickness of cross-linked methyl silicone (HP1, Hewlett-Packard). The column temperature was programmed from 120° C to 295° C at 30° C per minute with a hold time of 20 minutes at 295° C. The split ratio for the GC was 10:1.

*Liquid Chromatographic Procedures.* The analytical column was a 30 cm x 3.9 mm i.d. octadecylsilane column (Waters Associates) or a 30 cm x 3.9 mm i.d. Bondex C<sub>18</sub> column (Phenomenex). The steroids (0.1 mg/mL) were dissolved in HPLC grade methanol and chromatographed using a mobile phase of HPLC grade methanol and water of varying proportions. The mobile phase flow rate was 1.0 mL/min and the detector was operated at 0.1 or 0.5 AUFS. A 5  $\mu$ L aliquot of each steroid solution was injected into the liquid chromatograph.

### RESULT AND DISCUSSION

The anabolic steroids can be classified as non-esters or 17-esters. The non-esters include testosterone, methyltestosterone, nortestosterone (nandrolone), methandrostenolone, fluoxymesterone, boldenone (dehydrotestosterone), methandriol, oxandrolone, oxymetholone, and stanozolol. Of these derivatives, nandrolone, fluoxymesterone, and stanozolol have greater anabolic than androgenic activity. Testosterone, nandrolone, and boldenone are relatively ineffective when taken orally since they are readily inactivated by oxidation of the alcohol moiety at C-17 and reduction of the 4,5-double bond. Methandrostenolone, methyltestosterone, and fluoxymesterone have an additional methyl substituent at C-17 and this additional substituent at C-17 slows oxidative inactivation in the liver. As a result, these steroids display greater efficacy when administered orally. Figure 1 shows the structures of some of the more commonly encountered of the anabolic steroids.



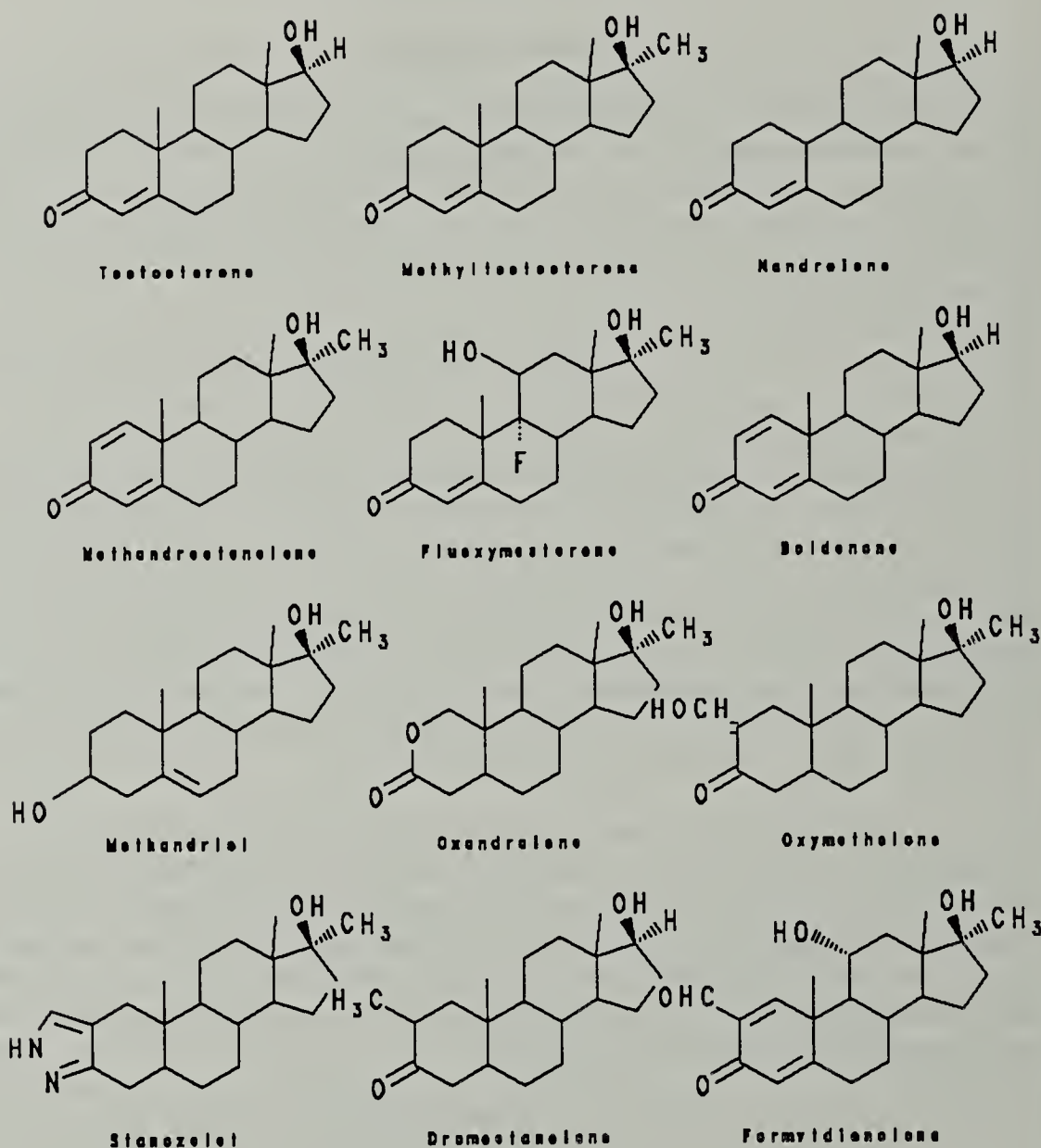





Figure 1. Structures of some commonly encountered anabolic/androgenic steroids.

The ester anabolic steroids include C-17 ester derivatives of testosterone, nandrolone, boldenone, dromostanolone, and methenolone. These products are marketed as oily solutions for intramuscular administration. These oily solutions diffuse from the site of injection to the circulatory system when the esters are hydrolyzed by plasma esterases to yield active anabolic steroids. At least one anabolic steroid (formebulone, formyldienolone) is marketed as an aqueous solution with lidocaine (Esiclene). A table of the more common acids used in the formulation of the C-17 anabolic steroid esters is given below (Table 1).

## Anabolic Steroids

TABLE OF ACIDS USED TO PREPARE STEROID ESTERS

ACID	ESTER	STRUCTURE
Acetic	Acetate	$\text{CH}_3\text{COOH}$
Benzoic	Benzoate	 $\text{COOH}$
Cyclopentylpropionic	Cypionate	 $\text{CH}_2\text{CH}_2\text{COOH}$
Decanoic	Decanoate	$\text{CH}_3(\text{CH}_2)_8\text{COOH}$
Heptanoic	Enanthate	$\text{CH}_3(\text{CH}_2)_5\text{COOH}$
Isocaproic	Isocaproate	$(\text{CH}_3)_2\text{CHCH}_2\text{CH}_2\text{COOH}$
Stearic (Octadecanoic)	Oleate	$\text{CH}_3(\text{CH}_2)_{16}\text{COOH}$
Phenylpropionic	Phenylpropionate	 $\text{CH}_2\text{CH}_2\text{COOH}$
Propionic	Propionate	$\text{CH}_3\text{CH}_2\text{COOH}$
Undecanoic	Undecanoate	$\text{CH}_3(\text{CH}_2)_9\text{COOH}$
10-Undecenoic	Undecylenate	$\text{CH}_2\text{-CH}(\text{CH}_2)_8\text{COOH}$
Valeric (Pentanoic)	Valerate	$\text{CH}_3(\text{CH}_2)_3\text{COOH}$

Testosterone (Figure 2), methyltestosterone, nandrolone, and fluoxymesterone all have a conjugated enone system (C-3, C-4, C-5) which is the primary chromophore in these molecules. As a result, all four of these compounds have similar UV absorption maxima at approximately 241 nm and have similar molar absorptivities. Methandrostenolone (Figure 3) and boldenone both have a dienone chromophore in the A-ring, and as a result of this more extensive conjugated  $\pi$ -electron system, display absorption maxima at 245 nm. Danazol (Figure 4), with an isoxazole ring fused to the A-ring, has a conjugated triene chromophore and this system has an absorption maximum at 285 nm, considerably higher than typical anabolic steroids. Stanazolol (Figure 5) with a pyrazole ring fused to the A-ring exhibits an absorption maximum at 224 nm. The UV properties of the anabolic steroids in the 240-255 nm region make these compounds excellent candidates for HPLC with UV detection.

Tablet preparations containing anabolic steroids may be dissolved in an appropriate amount of methyl alcohol and analyzed by UV, HPLC, and GC/MS. When the sample matrix is an oil, a small amount of the sample oil is placed in a test tube and extracted with methanol. The upper methanol layer will contain the anabolic steroid (ester or non-ester), preservatives such as benzyl alcohol or benzyl benzoate, and certain polar components from the oil. Methanolic extracts prepared

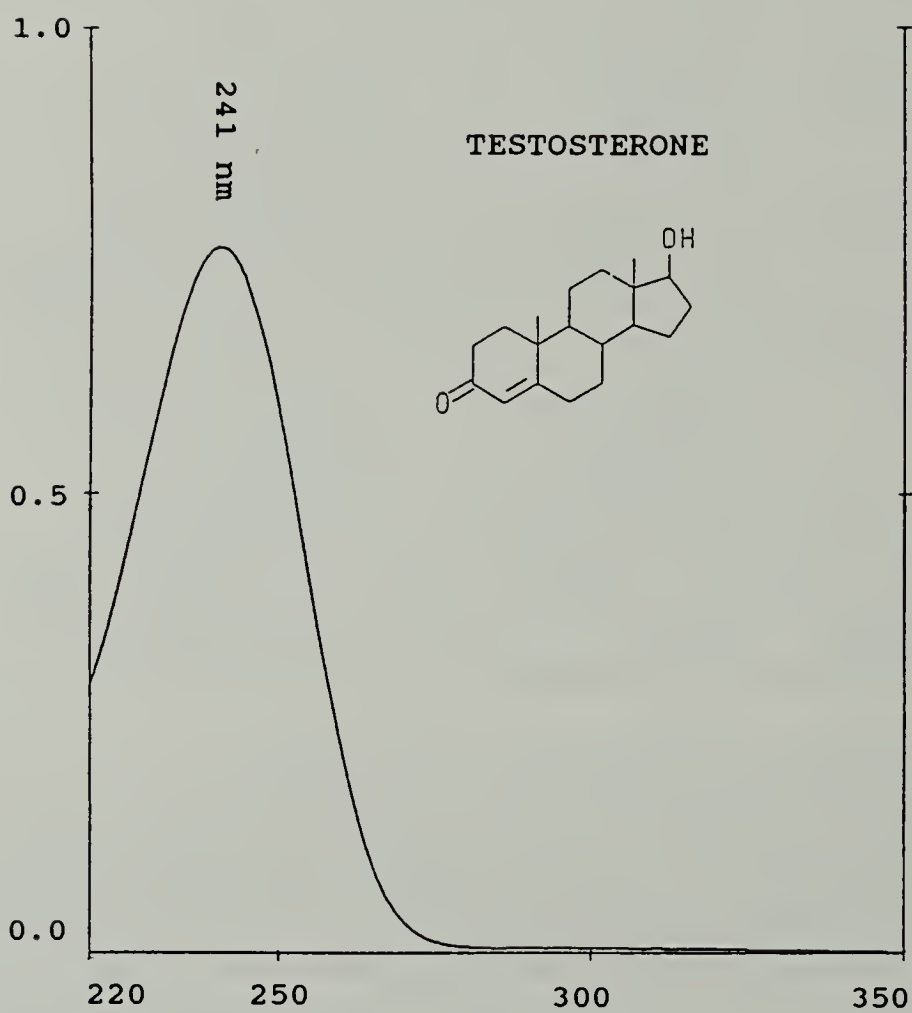


Figure 2. Ultraviolet absorption spectrum of testosterone.



## Anabolic Steroids

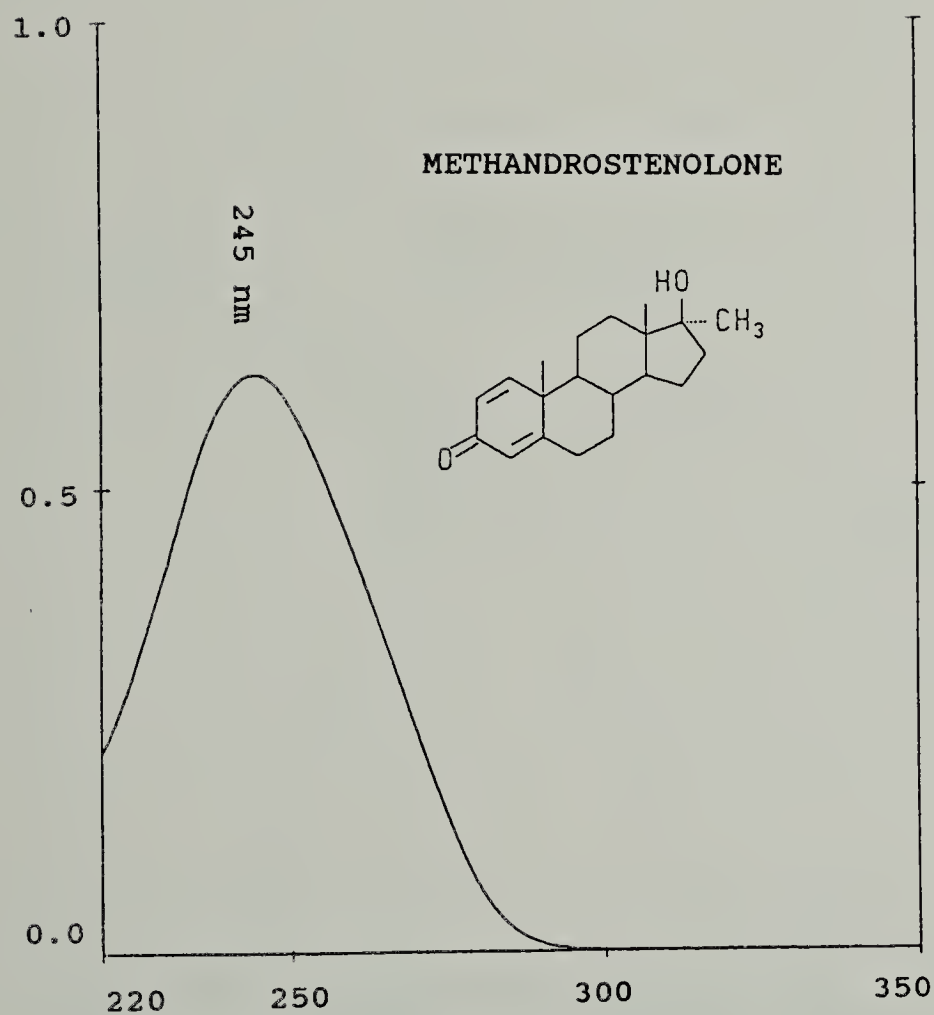


Figure 3. Ultraviolet absorption spectrum of methandrostenolone.

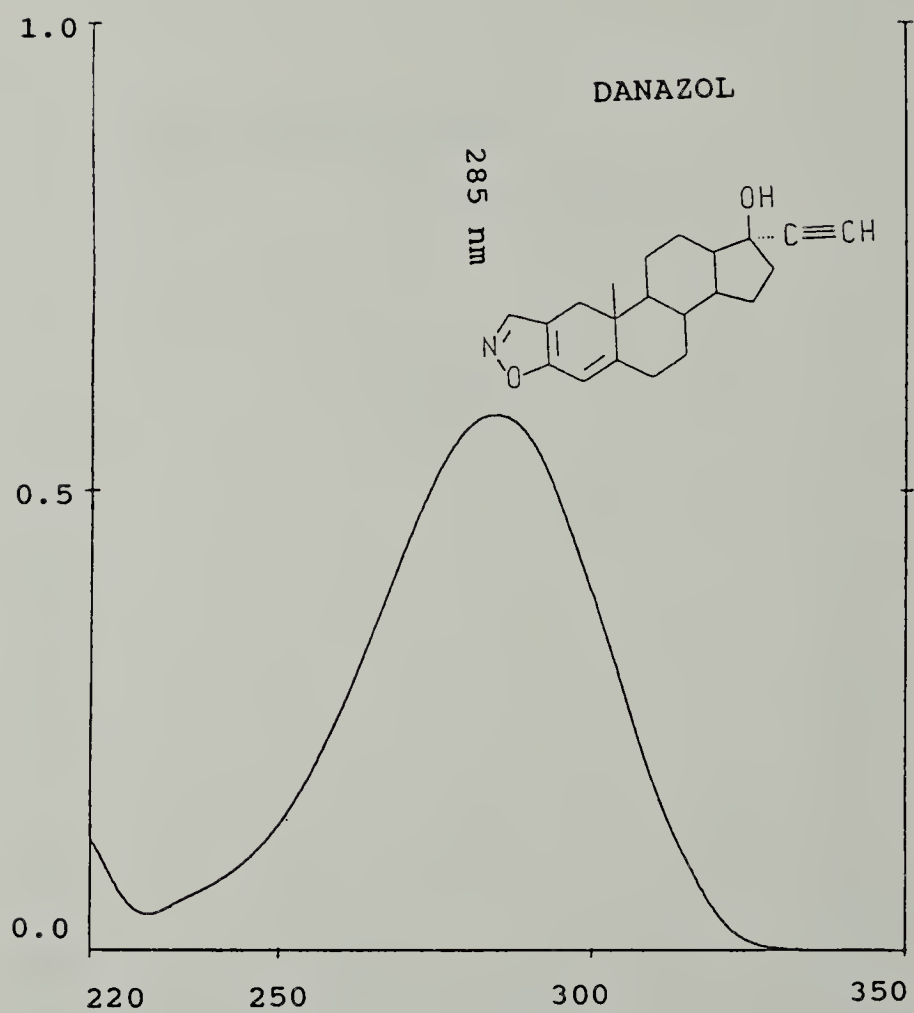


Figure 4. Ultraviolet absorption spectrum of danazol.

## Anabolic Steroids

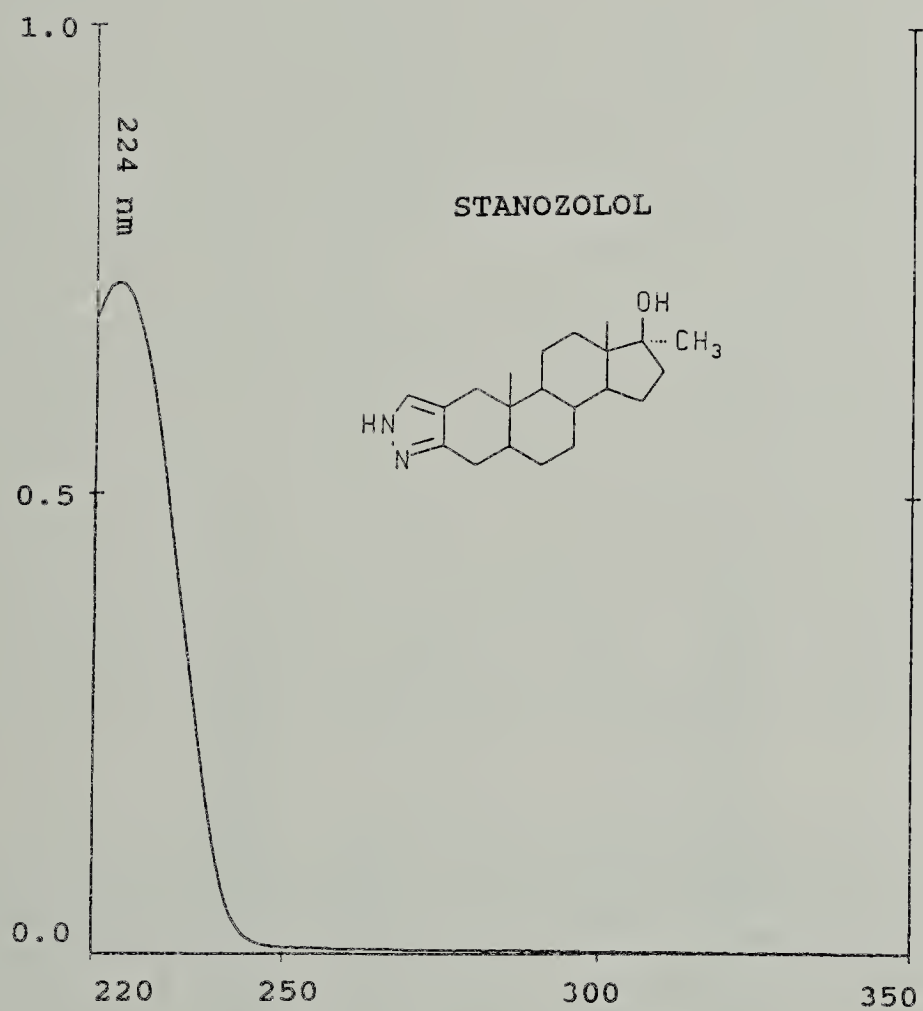


Figure 5. Ultraviolet absorption spectrum of stanozolol.



in such a manner have been found to be suitable for HPLC and GC/MS. Dilutions or concentrations of the methanol layer may be necessary to obtain a suitable detector response.

The liquid chromatographic properties of the 17-hydroxy anabolic steroids have been determined using various reversed phase systems consisting of different manufacturers octadecylsilane ( $C_{18}$ ) stationary phases. The separation of nandrolone, testosterone, methyltestosterone, and methandrostenolone is shown in Figure 6. The separation was achieved using a mobile phase of methanol:water (7:3) at a flow rate of 1.0 mL/min. The elution order of the first three steroids closely parallels expected lipophilicities. For example, nandrolone differs in its structure from testosterone in that it lacks a methyl substituent at C-19. As a result nandrolone is somewhat less lipophilic and elutes prior to testosterone. Also, methyltestosterone contains one more methyl group than testosterone (at C-17) and elutes after testosterone due to its increased lipophilicity. Introduction of a second double bond at positions C-1 and C-2 of methyltestosterone yields methandrostenolone. This modification results in increased polarity, therefore methandrostenolone elutes prior to testosterone and methyltestosterone. Methandrostenolone and nandrolone have similar retention properties in this chromatographic system. These two steroids can however be distinguished by their difference in absorption spectra as evidenced in Figure 6. The dienone chromophore of methandrostenolone results in a significantly higher absorbance at 280 nm. Figure 7 is the chromatogram of boldenone, nandrolone, testosterone, methyltestosterone, and danazol, showing the higher absorbance at 280 nm of boldenone due to the dienone chromophore and the significantly different absorption properties of danazol resulting from the fusion of the isoxazole ring to the A-ring.

The reversed phase liquid chromatographic properties of the 17-hydroxy steroid esters show their retention to be based significantly on the relative hydrophobicity of the acid moiety. Shown in Figure 8 is the chromatogram of some of the less lipophilic steroid esters. The separation was made with a Bondex  $C_{18}$  column using a mobile phase of 85 percent methanol in water. In all cases the esterified steroid has a higher capacity factor (longer retention) than the corresponding unesterified 17-hydroxy steroid. The acetate esters elute first followed by the more lipophilic esters having a higher hydrophobic surface area. Figure 9 shows the separation of some of the more lipophilic esters of boldenone, nandrolone, and testosterone. It should be pointed out that chain branching can cause considerable deviation in elution order. For example, the undecylenate ester of boldenone, although an 11-carbon ester, elutes before nandrolone decanoate. The additional polarity of the terminal olefinic bond coupled with the dienone structure of the A-ring are responsible for decreased retention of boldenone undecylenate. Figure 10 shows the separation of testosterone, epitestosterone, and the most common testosterone esters using a  $\mu$ Bondapak  $C_{18}$  column. The higher carbon number esters of testosterone show the same elution order trends as previously described. The 6-carbon isocaproate elutes before the 7-carbon enanthate while the 8-carbon cypionate and the 10-carbon decanoate show higher retention.

## Anabolic Steroids

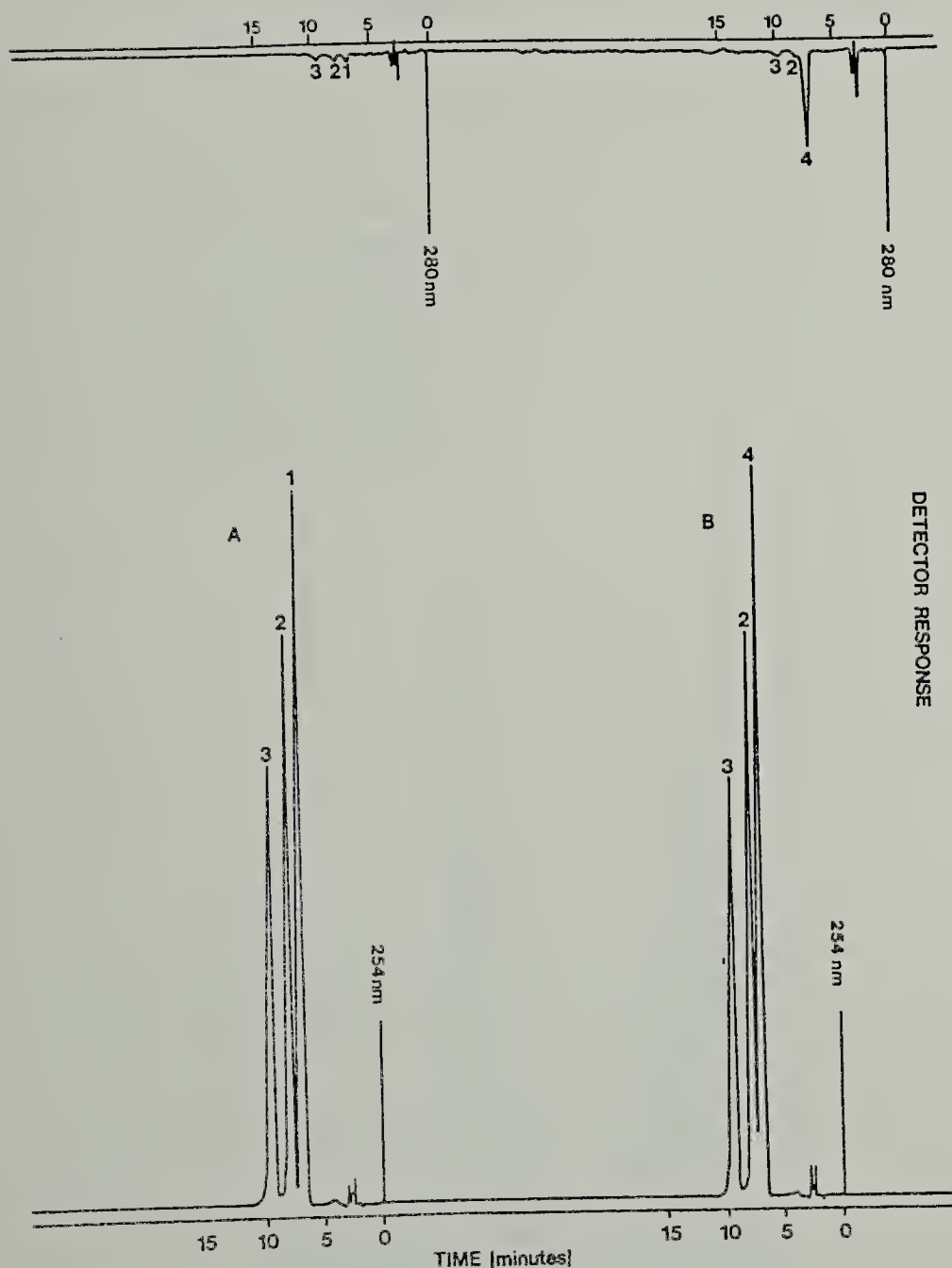


Figure 6. Reversed phase liquid chromatographic separation of some 17-hydroxy steroids. (A) peak 1 = nandrolone, 2 = testosterone, 3 = methyltestosterone, (B) peak 4 = methandrostenolone, 2 and 3 same as chromatogram A.

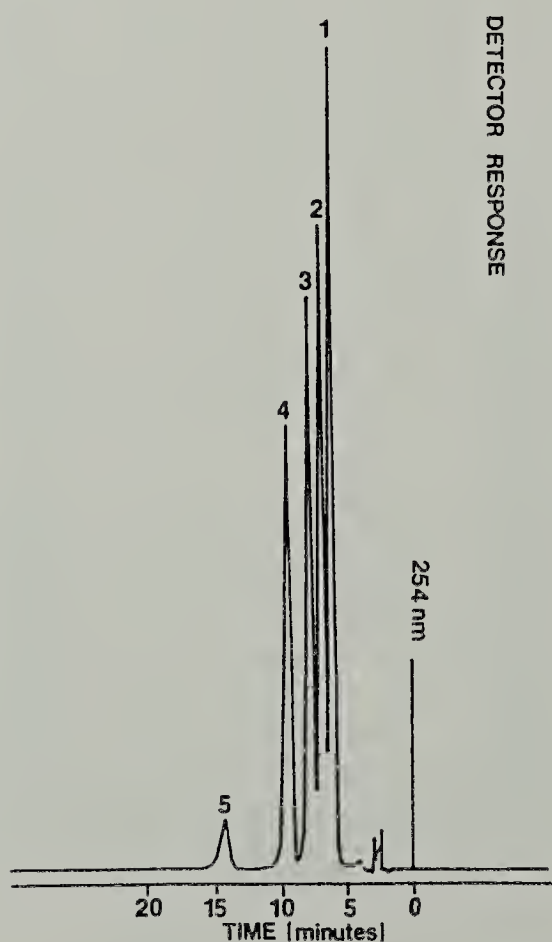
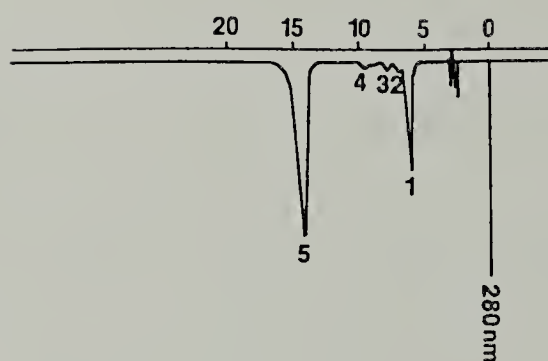


Figure 7. Reversed-phase liquid chromatographic separation of (1) boldenone, (2) nandrolone, (3) testosterone, (4) methyltestosterone, and (5) danazol.



## Anabolic Steroids

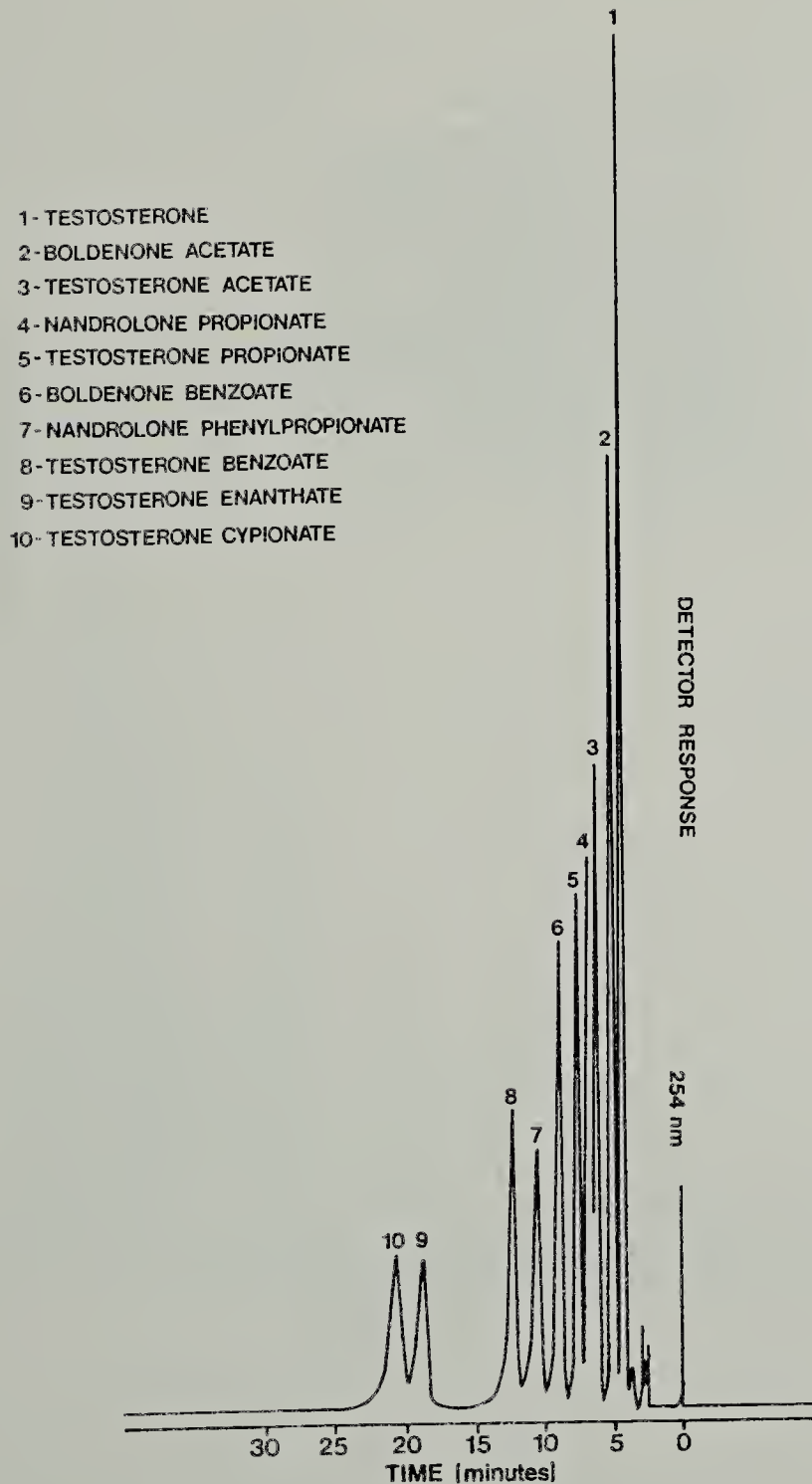


Figure 8. Liquid chromatographic separation of some less lipophilic steroids. Bondex  $C_{18}$  stationary phase and a methanol: water (7:3) mobile phase at 1.0 mL/min.

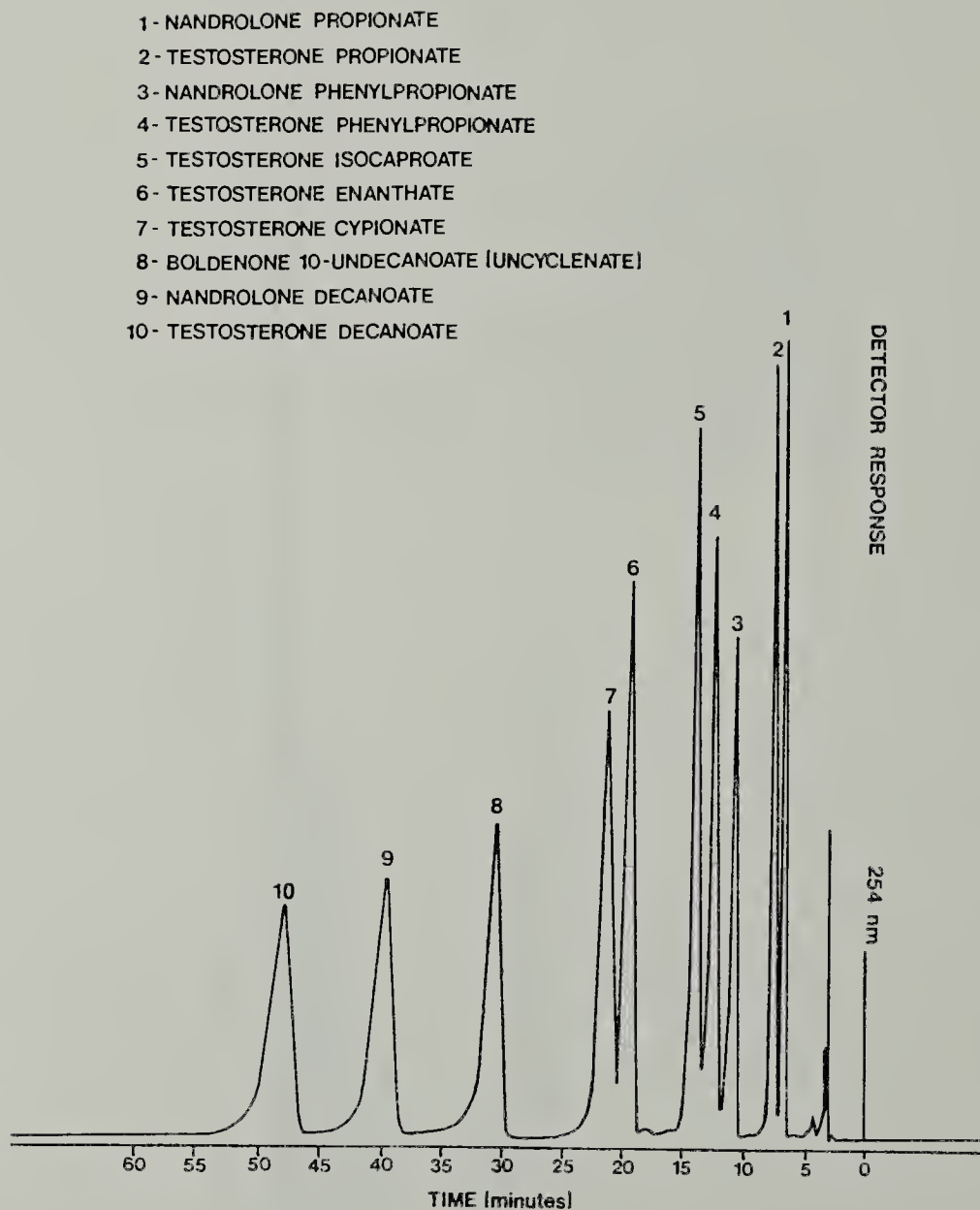


Figure 9. Liquid chromatographic separation of some lipophilic steroid esters of boldenone, nandrolone, and testosterone. Bondex  $C_{18}$  stationary phase and a methanol:water (85:15) mobile phase at 1.0 mL/min.

## Anabolic Steroids

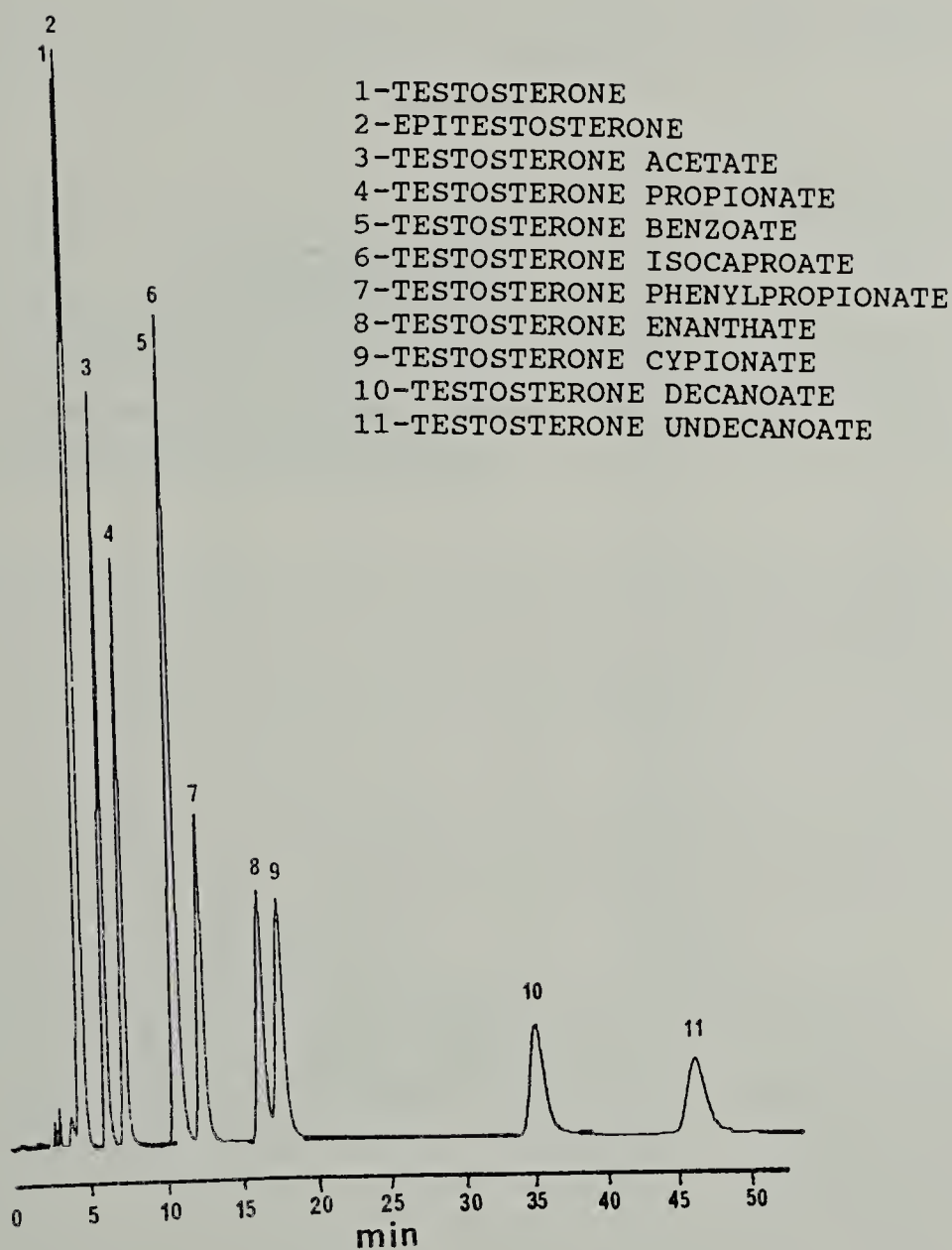


Figure 10. Liquid chromatographic separation of testosterone, epitestosterone, and the more common esters of testosterone.  $\mu$ Bondapak  $C_{18}$  stationary phase and a methanol:water (85:15) mobile phase at 1.0 mL/min.



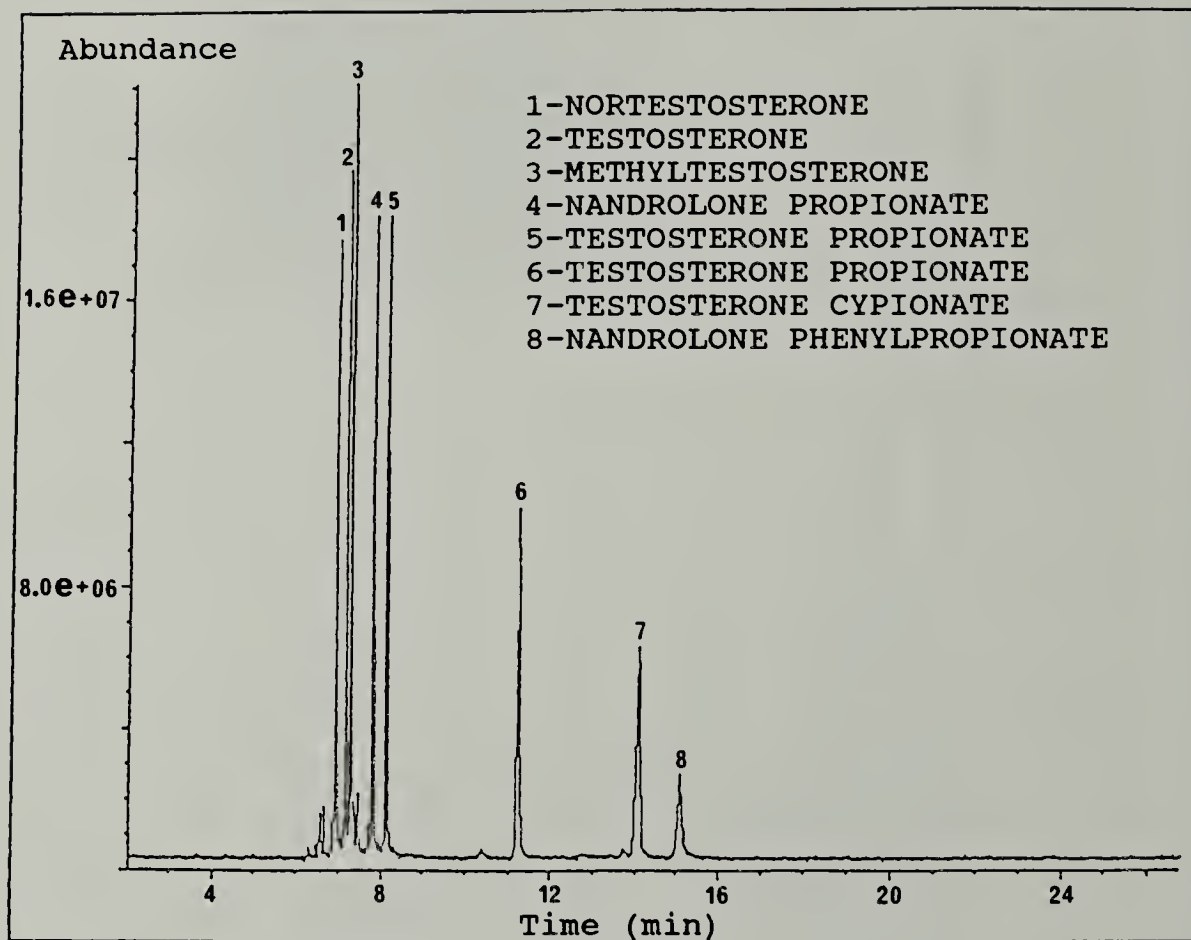


Figure 11. Total ion chromatogram of a steroid mixture obtained via a 12.5 m x 0.20 mm i.d. column with a 0.33  $\mu$  film thickness of methyl silicone under temperature program conditions.

## Anabolic Steroids

Capillary GC/MS is an effective method to positively identify both the non-ester and 17-ester steroids. Separations of the non-ester and 17-ester steroids have been obtained on various manufacturers methyl silicone columns under both isothermal and temperature program conditions.

Since anabolic steroids were placed on control in Alabama numerous preparations have been submitted to the Alabama Department of Forensic Sciences for analysis. Figure 12 is the liquid chromatographic separation of a forensic sample which was labeled as "Sostenon 250". Extraction of a portion of the oily solution was made into methanol and subjected to liquid chromatography and GC/MS confirming the solution as a mixture of four testosterone esters (propionate, phenylpropionate, isocaproate, and decanoate). Figure 13 is the mass spectrum of testosterone isocaproate and Figure 14 is the mass spectrum of testosterone decanoate from this sample.

Another forensic sample which has been submitted was labeled "Masteron". Intelligence information indicated that this sample was shipped to Alabama from Spain. Masteron has been used as an adjunct in the treatment of breast cancer. GC/MS showed the sample to be dromostanolone propionate. Shown is Figure 15 is the mass spectrum of the methanol extract of this oily solution.

A sample which was subjected to analysis was an aqueous solution labeled "Esiclone". A literature search indicated that this solution was a mixture of formyl dienolone (formebulone) and lidocaine. The sample was subjected to HPLC and GC/MS and the mass spectrum which confirmed the solution to contain formyl dienolone is shown in Figure 16.

## SUMMARY

In summary, the 17-hydroxy anabolic steroids and ester derivatives can be separated under reversed-phase liquid chromatographic conditions. These compounds have been separated on several  $C_{18}$  stationary phases under isocratic conditions using a solvent system of 70% methanol in water for the non-esters and 85% methanol in water for the esters. The identity of all steroids is confirmed by GC/MS. Using both the liquid chromatographic and GC/MS analysis techniques, a number of clandestine steroid samples have been analyzed.

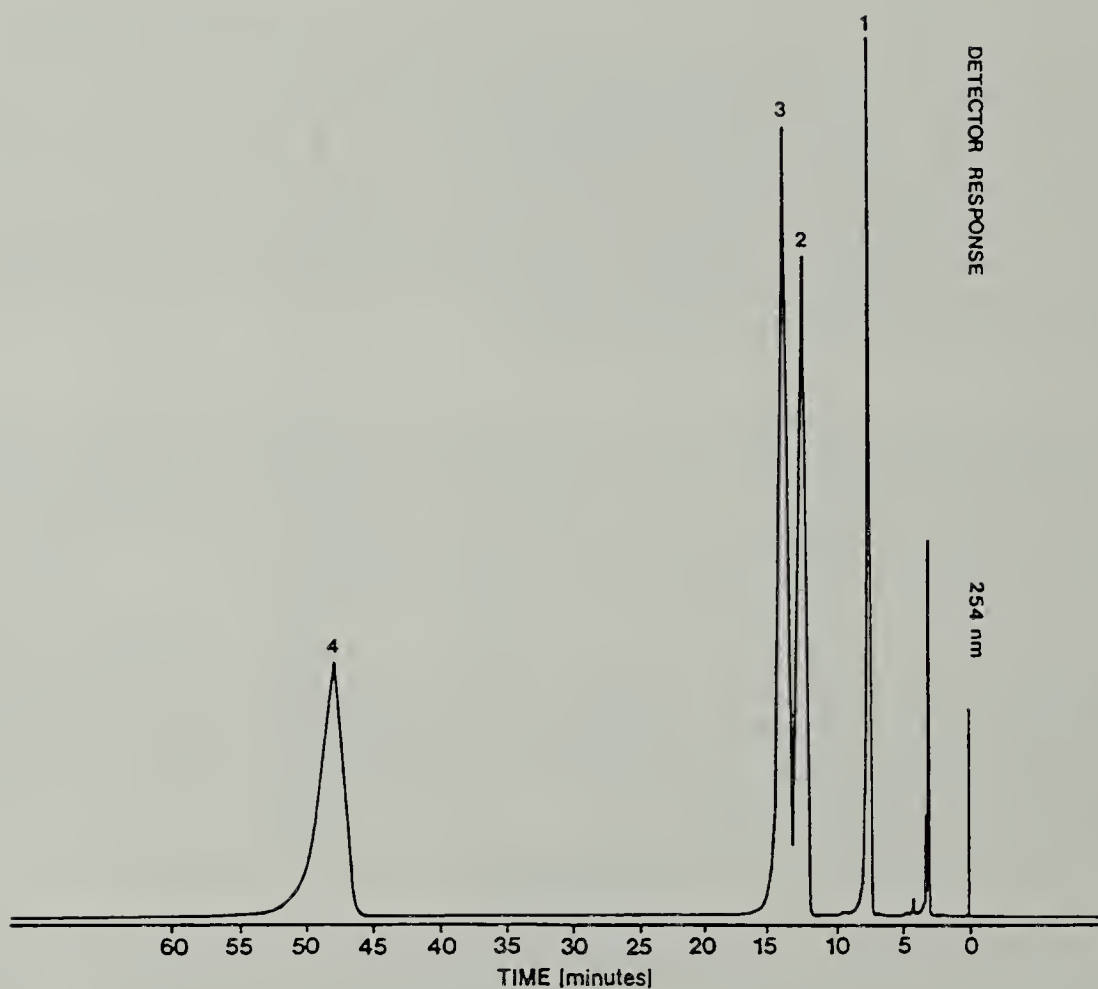


Figure 12. Liquid chromatographic separation of a forensic sample containing testosterone esters. Peaks: (1) propionate, (2) phenylpropionate, (3) isocaproate, (4) decanoate.



## Anabolic Steroids

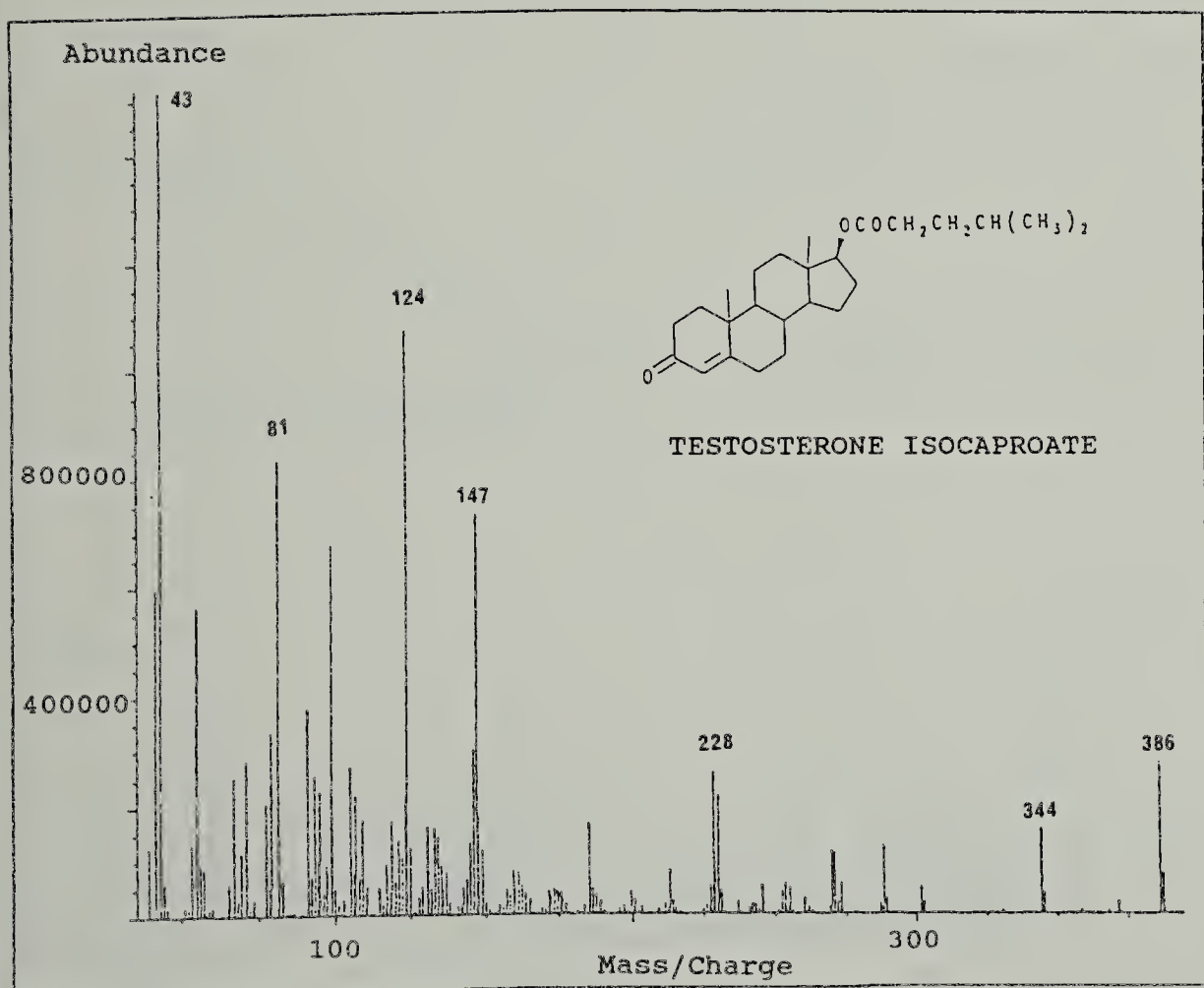


Figure 13. Mass spectrum of testosterone isocaproate obtained from forensic sample.

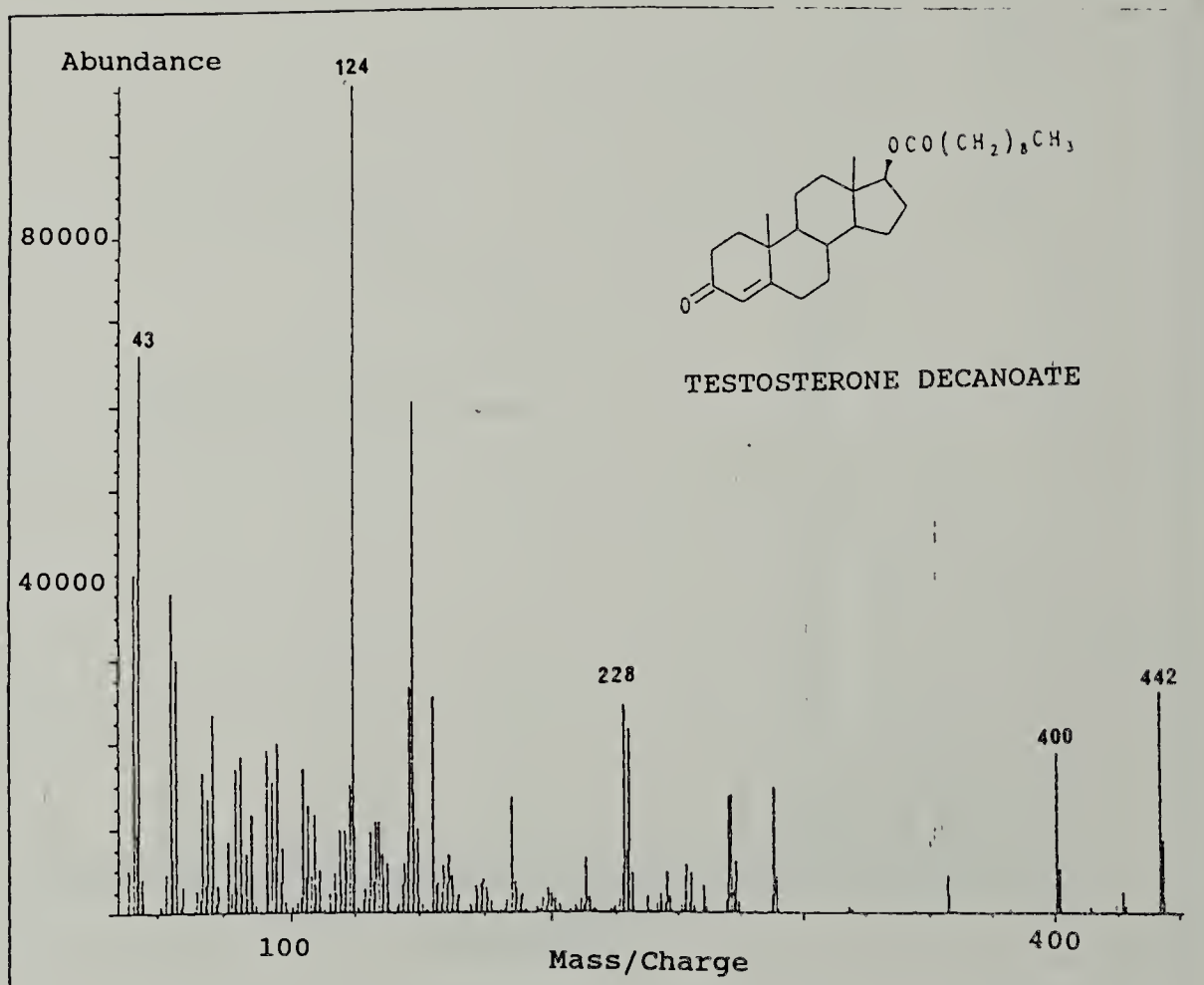


Figure 14. Mass spectrum of testosterone decanoate obtained from a forensic sample.

## Anabolic Steroids

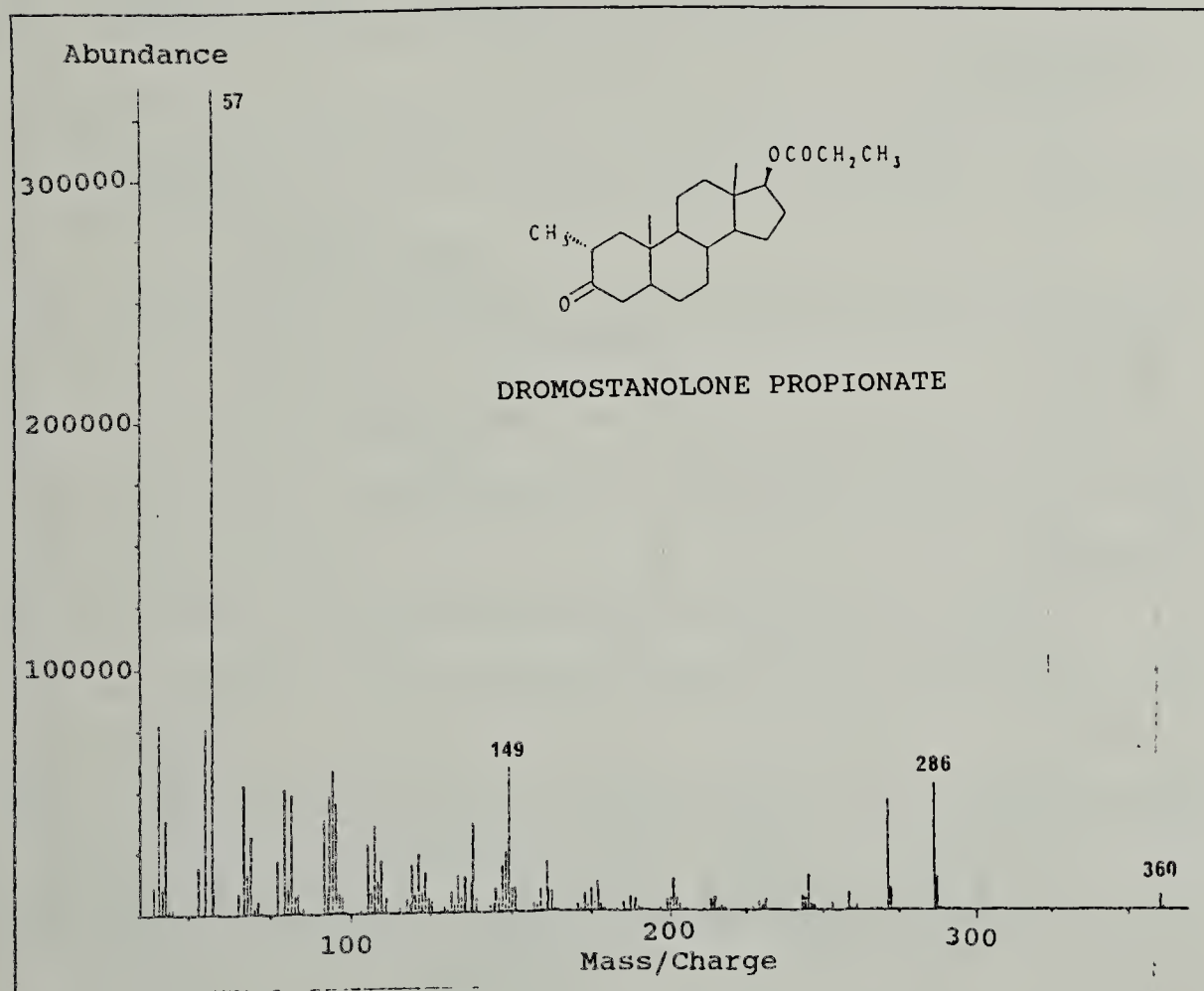


Figure 15. Mass spectrum of dromostanolone propionate from a forensic sample.



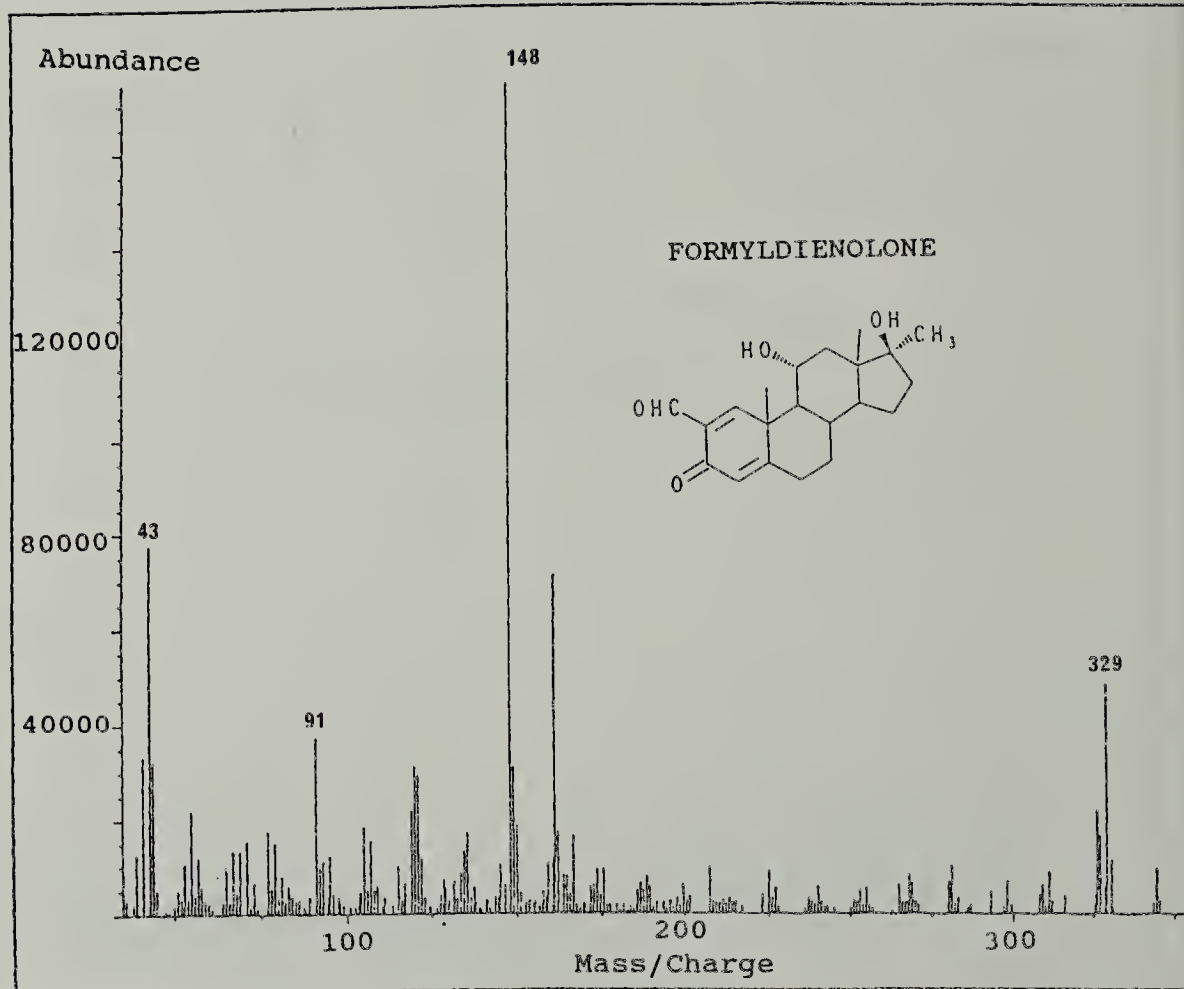


Figure 16. Mass spectrum of formyldienolone from a forensic sample.

## Anabolic Steroids

### REFERENCES

1. R. G. Rahwan. The pharmacology of androgens and anabolic steroids. *Am. J. Pharm. Ed.* 52: 167-177 (1988).
2. William O. Foye. "Principles of Medicinal Chemistry," 2nd ed. Lea and Febiger, Philadelphia, PA, 1981, pp. 547-553.
3. R. Voy. Illicit drugs and the athlete. *Am. Pharm.* 26: 39-42 (1986).
4. S. Helms and J. T. Pento. Anabolic steroid use by athletes. *US Pharmacist* Jan: 49-52 (1985).
5. H. A. Haupt and G. D. Rovere. Anabolic steroids: a review of the literature. *Am. J. Sports Med.* 12: 469-484 (1984).
6. J. E. Wright. Anabolic steroids and athletes. *Exerc. Sport Sci.* 8: 149-202.
7. W. V. Moore. Anabolic steroid use in adolescence (Editorial). *JAMA* 260: 3404-3406 (1988).
8. C. Birdsong. Why athletes use drugs. *Am. Pharm.* 26: 43 (1986).
9. M. B. Mellion. Anabolic steroids in athletes. *Am. Fam. Phy.* 30: 113-119 (1984).
10. M. W. Kibble and M. B. Ross. Adverse effects of anabolic steroids in athletes. *Clin. Pharm.* 6: 686-692 (1987).
11. S. Penn. Muscling in: as ever more people try anabolic steroids; traffickers take over. *Wall Street J.* 10/4: 1 (1988).
12. T. J. Limbird. Anabolic steroids in the training and treatment of athletes. *Compr. Ther.* 11: 25-30 (1985).
13. R. H. Strauss, M. T. Liggett and R. R. Lanese. Anabolic steroid use and perceived effects in ten weight-trained women athletes. *JAMA* 253: 2871-2873 (1985).
14. G. McKillop, I. C. Todd and D. Ballantyne. Increased left ventricular mass in the bodybuilder using anabolic steroids. *Br. J. Sports Med.* 20: 151-152 (1986).
15. H. G. Pope, Jr. and D. L. Katz. Bodybuilder's psychosis (Letter). *Lancet* 1: 863 (1987).

16. Anonymous. Halt marketing of anabolic steroids. *Pharm. Times* 52: 95 (1986).
17. P. S. Salva. Anabolic steroids and Sports (Letter). *JAMA* 258: 1608 (1987).
18. J. C. Wagner. Substance-abuse policies and guidelines in amateur and professional athletics. *Am. J. Hosp. Pharm.* 44: 305-310.
19. H. G. Wilms. Memo on black-market athletic drugs to regional FDA directors, district directors, resident post. April 4, 1986.



## COCAINE: METHODS OF ANALYSIS<sup>1</sup>

F. Taylor Noggle, Jr.  
*Alabama Department of Forensic Sciences*  
*P. O. Box 3510*  
*Wire Road*  
*Auburn, AL 36830*

and

Jack DeRuiter  
C. Randall Clark  
*Department of Pharmacal Sciences*  
*School of Pharmacy*  
*Auburn University, AL 36849*

Cocaine is a naturally occurring alkaloid obtained from the leaves of the coca bush *Erythroxylum coca*, a shrub grown on the eastern slopes of the Andes Mountains of South America. Cocaine is produced within eighteen months to three years and continues to be produced for the 40 year life span of the coca plant.

Cocaine has been used for more than 2000 years by the Indians of South American in the form of the coca leaf, and its use in the United States dates back to the nineteenth century. Cocaine was the first local anesthetic to be discovered, however its legitimate use today is limited to local anesthesia in nasal surgery. Its importance as a drug of abuse is evidenced by the fact that cocaine is now the most frequently encountered drug submitted to laboratories of the Alabama Department of Forensic Sciences.

The leaves of the coca plant contain a number of alkaloids. Cocaine is the most abundant alkaloid and may be present in percentages from 0.6% to 1.8%. Ecgonine, cinnamoylcocaines, anhydroecgonine, anhydroecgonine methyl ester, ecgonine methyl ester, tropacocaine, benzoylecgonine,  $\alpha$ - and  $\beta$ -truxillines, hyrines, and cocatannic acid are some of the other alkaloids which have been reported in the coca leaf.

The clandestine preparation of cocaine from the coca leaf is a process which requires 4-5 days. The dried coca leaves are treated with an alkaline solution - lime, sodium carbonate, or potash - which begins to extract the alkaloids from the leaf.

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<sup>1</sup>Manuscript received 11 September 1992; accepted 1 October 1992.

The next day the leaves are soaked in kerosene. The leaves are sometimes pressed, like grapes, to help extract the alkaloid-rich kerosene from the soggy plant material. When the alkaloids in the leaf have fully dissolved into the kerosene, the dead, blackened leaf is skimmed off and sulfuric acid is added to the mix. The acid extracts the alkaloids now contained in the kerosene. The kerosene is siphoned off and alkali added to neutralize the acid. A gummy, grayish goo known as coca paste collects at the bottom of the vat. The paste producers in Bolivia and Peru usually sell their product to the Columbians. In Columbian villages paste is mixed with tobacco and smoked as *bazuko*.

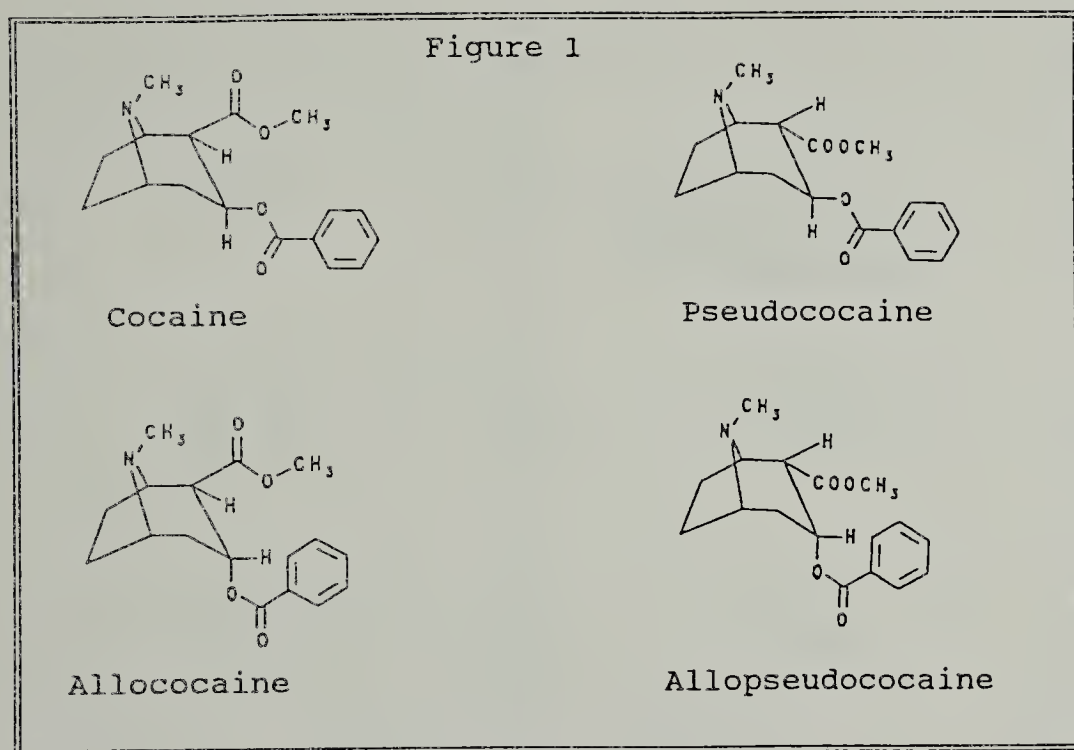
The Columbians refine most of the paste that they buy. The process continues with another kerosene wash with the alkaloids settling in layers. The mush crystals at the top are crude cocaine, about 60% pure. The crystals are scraped off, washed with alcohol, filtered, dried, and then dissolved in sulfuric acid. Potassium permanganate may be added at this point to oxidize the non-cocaine alkaloids (cinnamoylcocaines). What remains is filtered to remove other impurities. Ammonium hydroxide is added, and the resulting precipitate is again filtered and dried. What is left is essentially pure cocaine alkaloid known as cocaine base. It takes approximately 2 1/2 kilos of coca paste to produce one kilo of cocaine base.

To create cocaine hydrochloride, which is smuggled into this country, the base is dissolved in ether or acetone and precipitated with hydrochloric acid. Because of restrictions placed on the shipment of acetone and ether to Columbia, it is not uncommon for these solvents to be recycled and used several times. It takes approximately 5 gallons of acetone or ether to convert one kilo of cocaine base to cocaine hydrochloride. The insoluble cocaine hydrochloride is filtered through filter paper, cheese cloth, or a bed sheet. The resulting product is dried under the sun, heat lamps, or in a microwave oven.

The pharmaceutical manufacture of cocaine is a different process. The coca leaf alkaloids are hydrolyzed with hydrochloric acid and heat to ecgonine. Ecgonine is then converted to methyl-ecgonine with boron trichloride-methanol and finally to cocaine with benzoyl chloride in benzene. The synthetic process results in a high purity cocaine unlike the product which is manufactured in clandestine laboratories.

The cocaine molecule contains four chiral centers in its bicyclic system giving rise to eight enantiomers or four diastereomeric pairs. All four of the diastereomers (and their corresponding enantiomers) are known and have been given the trivial names cocaine, pseudococaine, allococaine, and pseudoallococaine (Figure 1). All four diastereomers have different physiochemical properties, including melting points, and can be separated by high performance liquid chromatography (HPLC) or thin layer chromatography. Gas chromatography has not proven to be effective since these alkaloids do not separate well and may undergo significant decomposition. The

## Cocaine

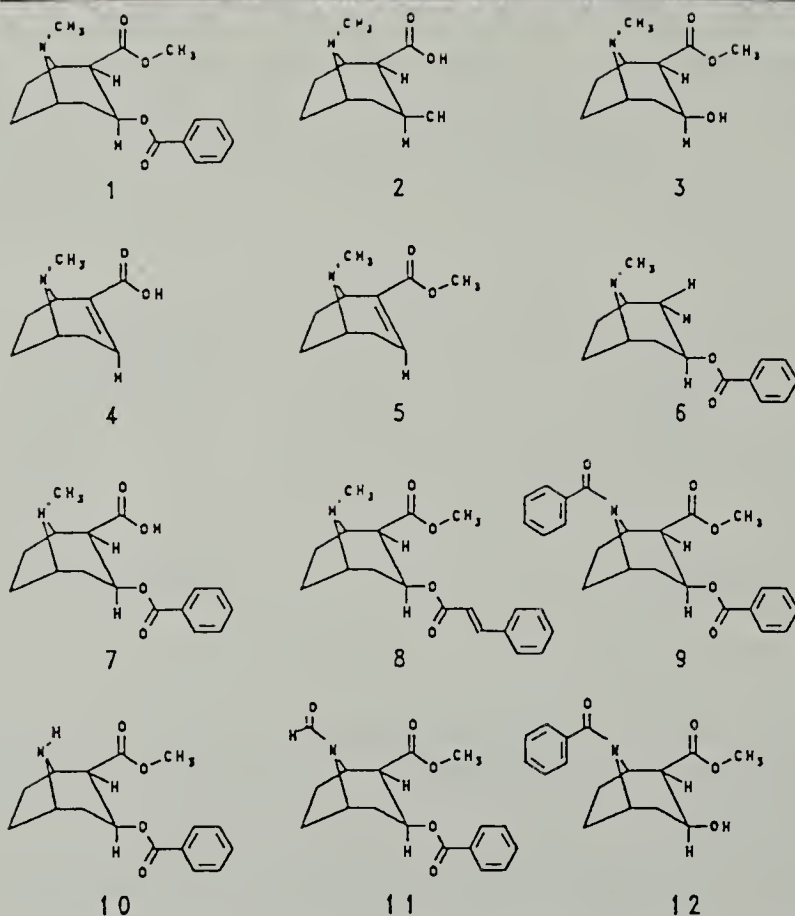


diastereomers can also be distinguished by infrared and nuclear magnetic resonance spectroscopy as well as microcrystalline tests and X-ray diffraction. Infrared spectroscopy, which will differentiate the diastereomers of cocaine as well as differentiate cocaine hydrochloride and other salt forms from cocaine base, is the primary analytical technique used by the Alabama Department of Forensic Sciences to identify cocaine. There is no legal requirement to identify the enantiomeric form of cocaine since Alabama law and Federal law control cocaine and its salts, isomers, derivatives, and salts of isomers and derivatives. At the Federal level it is necessary to differentiate salt forms of cocaine from cocaine base ("crack" cocaine) since possession or sale of cocaine base allows for more serious penalties. For example, possession or sale of 3-4 grams of cocaine base mandates a sentence of 41-51 months while possession or sale of 300-400 grams of cocaine hydrochloride mandates an equivalent sentence.

While cocaine is the major alkaloid produced by the coca plant, several ecgonine-like alkaloids and other impurities may be present in illicit cocaine samples. (Table I) For example, the cinnamoylcocaine methyl ester (*cis*- and *trans*-cinnamoylcocaine) are the most frequently identified of the non-cocaine alkaloids. HPLC can be used as an effective screening technique to identify the cinnamoylcocaines as well as numerous adulterants and diluents. The HPLC separation is carried out using a  $\mu$ -Bondapak  $C_{18}$  octadecylsilane column with a mobile phase of aqueous pH 3.0  $\text{NaH}_2\text{PO}_4$  buffer and methanol (2:1) at a flow rate



TABLE I



1-Cocaine; 2-Ecgonine; 3-Ecgonine Methyl Ester; 4-Anhydroecgonine; 5-Anhydroecgonine Methyl Ester; 6-Tropacocaine; 7-Benzoylecgonine; 8-Cinnamoylcocaine Methyl Ester; 9-N-Benzoylnorcocaine; 10-Norcocaine; 11-N-Formylcocaine; 12-N-Benzoylnorecgonine Methyl Ester

of 2.0 mL/min and monitored with UV detection at 254 nm and 280 nm. Figure 2 shows the separation of a sample of clandestine cocaine containing the cinnamoylcocaines. Figure 3 is the HPLC separation of cocaine, several local anesthetics commonly found as adulterants with cocaine, and benzoylecgonine, a hydrolysis product and major metabolite of cocaine.

Gas chromatography/mass spectrometry (GC/MS) is the method of choice for identifying the minor alkaloids which may be present in a cocaine sample. The minor alkaloids and other adulterants and diluents which are present in a sample may be useful in determining whether multiple samples may be from a common source.

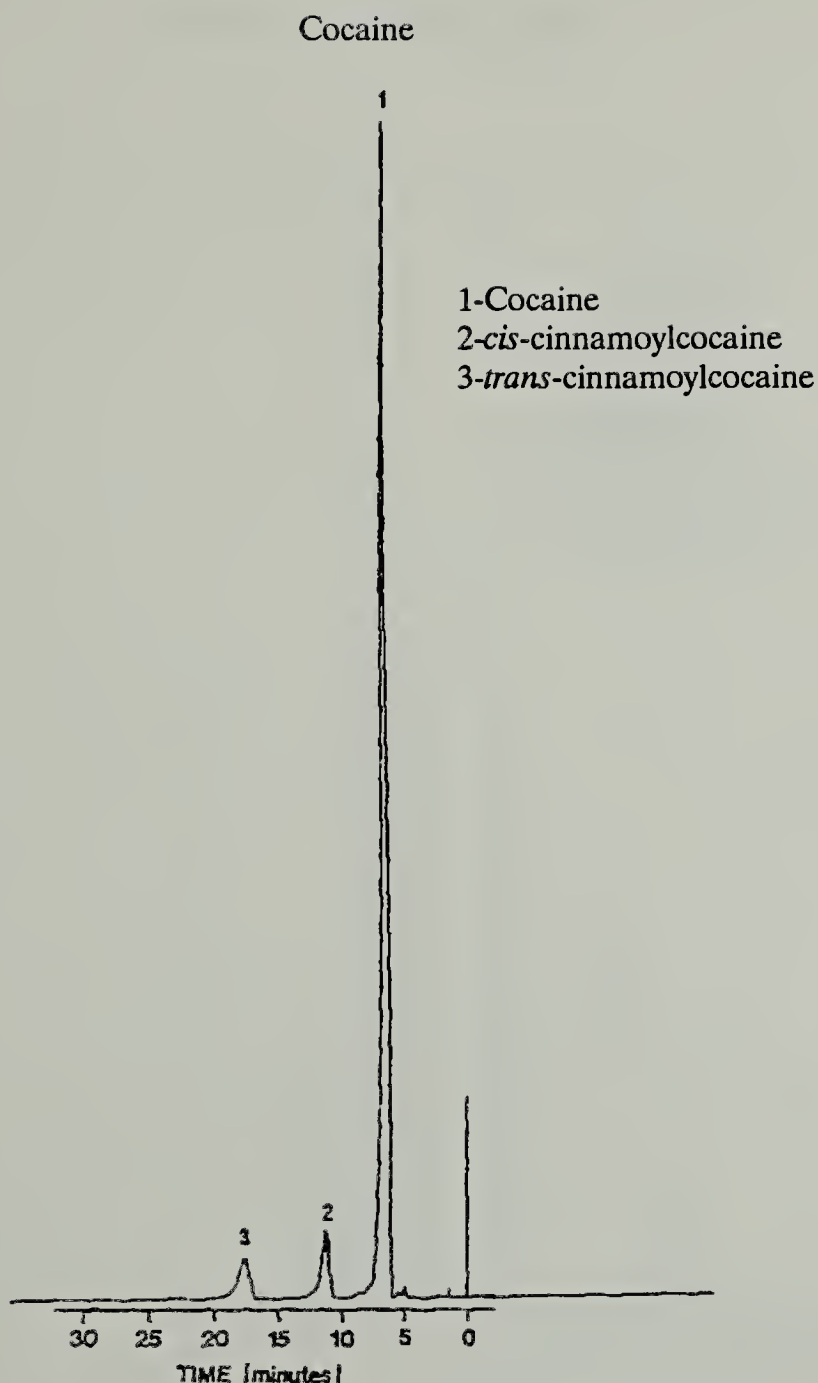


Figure 2

Samples suspected of containing cocaine are injected into a capillary gas chromatograph equipped with a 12.5 m x 0.20 mm id fused silica capillary column with a 0.33  $\mu$  film thickness of cross linked methyl silicone (HP1, Hewlett-Packard, Palo Alto, CA). The gas chromatograph is programmed at 70°C for 2.5 min and from 70°C to 170°C at a rate of 25° C/min and from 170° to 275°C at a rate of 12.0° C/min with a hold time of 6.0 min. The injector port is set at 230°C to prevent formation of certain artifacts. Mass spectra are recorded in the electron impact (EI) mode at an ionization voltage of 70 eV and a source temperature of 220°C.

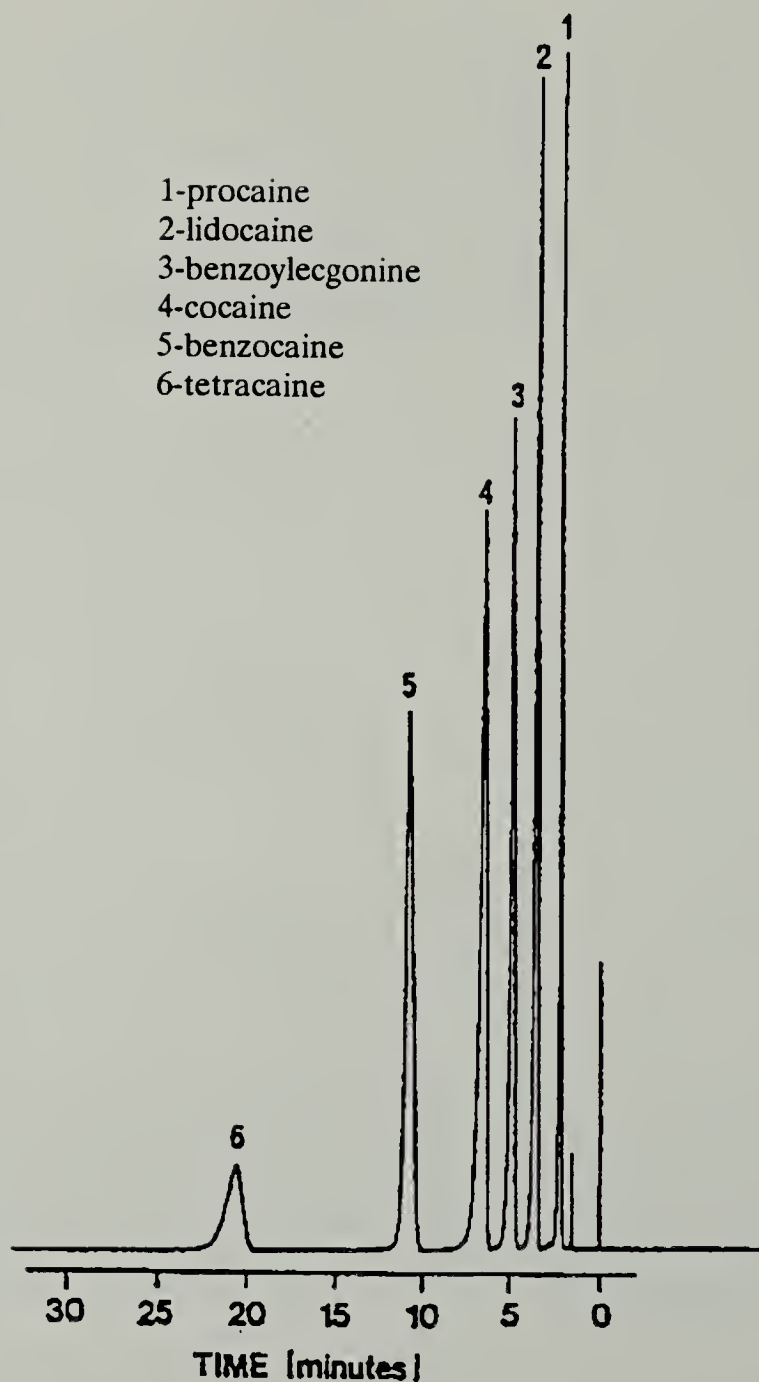


Figure 3

Figure 4 is the total ion chromatogram of a typical cocaine hydrochloride sample. Present in the sample are nine different identifiable components. Anhydroecgonine methyl ester has been reported as a naturally occurring product in coca leaves as well as an artifact of the gas chromatograph when the injection port temperature is set above 230°C. Anhydroecgonine methyl ester is formed after loss of benzoic acid from cocaine due to acid hydrolysis and finally elimination of water from ecgonine methyl ester. Anhydroecgonine methyl ester is a basic compound that



## Cocaine

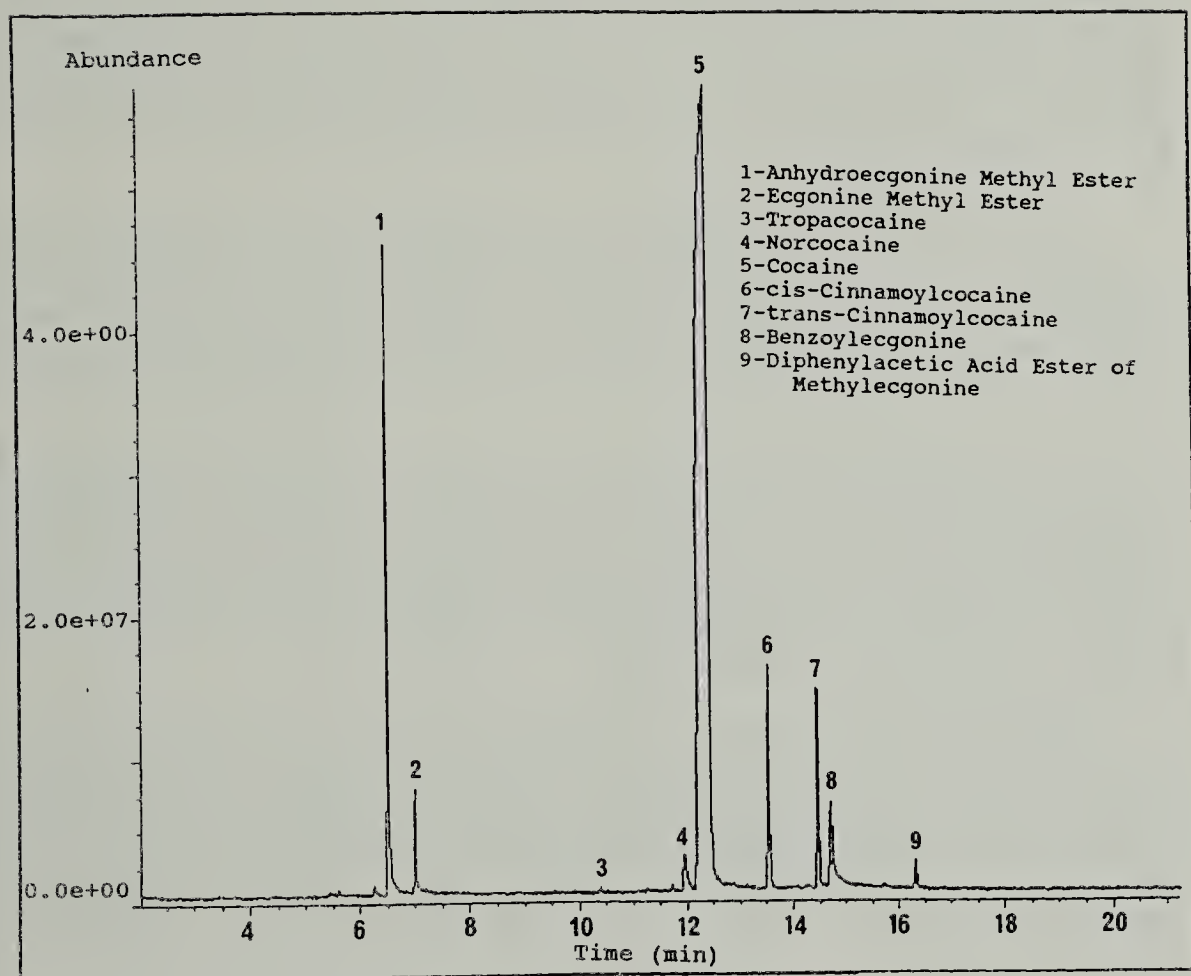


Figure 4

will coextract with cocaine. The potassium permanganate oxidation of cocaine to remove compounds containing double bonds will eliminate anhydroecgonine methyl ester. Negligible levels of *cis*- and *trans*-cinnamoylcocaine will mean negligible levels of anhydroecgonine methyl ester except where extensive hydrolysis of cocaine has occurred.

Ecgonine methyl ester (methyl ecgonine) is found as an alkaloid in coca leaves and is also a hydrolysis product of cocaine with lesser amounts derived from oxidation procedures. Ecgonine methyl ester will coextract with cocaine from the coca leaf. The primary source of ecgonine methyl ester appears to be from hydrolysis of cocaine due to decomposition after salt conversion.

Tropacocaine is a naturally occurring alkaloid in coca leaves and does not usually occur at concentrations greater than 1%. Some varieties of coca, depending on age of the plant and location where grown, will contain higher concentrations of tropacocaine. Tropacocaine does not occur in cocaine samples from decomposition of cocaine or related alkaloids and is therefore useful in classifying samples thought to be of common origin.

Norcocaine is a basic manufacturing by-product from permanganate oxidation of cocaine, a hydrolysis product from a Schiff's base intermediate during permanganate oxidation, and is also produced from demethylation of cocaine by diethyl ether containing elevated levels of peroxides. Norcocaine will coextract with cocaine.

*cis*-Cinnamoylcocaine and *trans*-cinnamoylcocaine are naturally occurring alkaloids found in the coca leaf and are not cocaine decomposition products. *cis*-Cinnamoylcocaine occurs at a higher concentration than the *trans*-isomer. Some or all of the cinnamoylcocaine are removed during clandestine potassium permanganate oxidation procedures. Cinnamoylcocaine concentrations are useful in classifying cocaine samples from a common origin.

Benzoylecgonine, present in coca leaves and a major metabolite identified in biological fluids, is a hydrolysis product of cocaine, and is produced in small quantities by potassium permanganate oxidation procedures. Benzoylecgonine is an amphoteric substance which will not coextract with cocaine in clandestine work-up procedures. The presence of benzoylecgonine in cocaine samples indicates that the sample has undergone hydrolysis.

"Crack" cocaine samples are a highly addictive, smokable form of cocaine. "Crack" samples are prepared by dissolving cocaine hydrochloride in water to which baking soda (sodium bicarbonate) has been added. The solution is cooled by adding cold (ice) water and the cocaine (base) or "crack" cocaine as it is now known will precipitate. This precipitate is broken into small pieces referred to as "rocks".

Figure 5 is the total ion chromatogram of a suspected "crack" sample. The major differences between this chromatogram and the chromatogram of cocaine hydrochloride are the presence of benzoic acid methyl ester and N-benzoylnorecgonine methyl ester and the absence of benzoylecgonine. Because benzoylecgonine is an amphoteric substance it would be expected to remain in the baking soda solution and would not be found in "crack" samples to an appreciable extent unless the sample has undergone hydrolysis. Benzoic acid methyl ester is probably a gas chromatographic artifact resulting from the presence of benzoic acid in the sample and methanol used to dissolve the sample. N-Benzoylnorecgonine methyl ester could be expected in illicit cocaine samples after demethylation of ecgonine methyl ester to yield norecgonine methyl ester followed by O-N-acyl migration of the benzoyl moiety to yield N-benzoylnorecgonine methyl ester.

## Cocaine

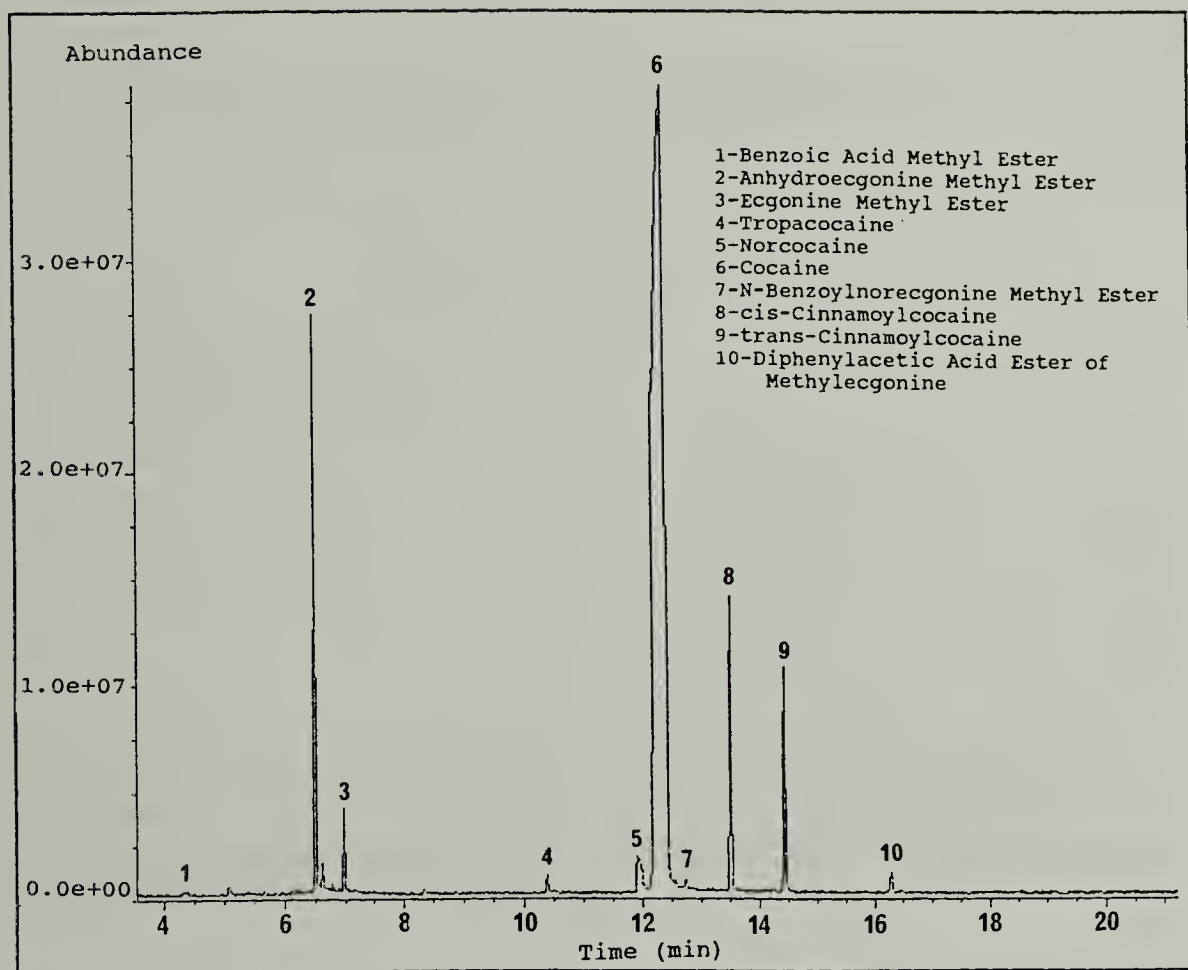


Figure 5

Should further characterization of cocaine samples be needed or desired, samples may be derivatized for capillary gas chromatography. (Figure 6) A 5-10 mg sample of cocaine base or cocaine hydrochloride is added to a suitable container. To this container is added 200  $\mu\text{L}$  of N,O-bis-(trimethylsilyl) acetamide (BSA). The container is sealed and heated at 80°C for 15 min to complete derivatization. The solution is allowed to cool at room temperature for 30 min and 2.0  $\mu\text{L}$  of the solution containing the trimethylsilyl-derivatives is injected into the GC/MS using the previously described conditions. Components not detected by the previous methods are benzoic acid, anhydroecgonine (ecgonidine), cinnamic acid, ecgonine, and the truxillic/truxinic acids. By selection of the appropriate internal standard, quantitative analysis may be able to verify samples which are from a common source.



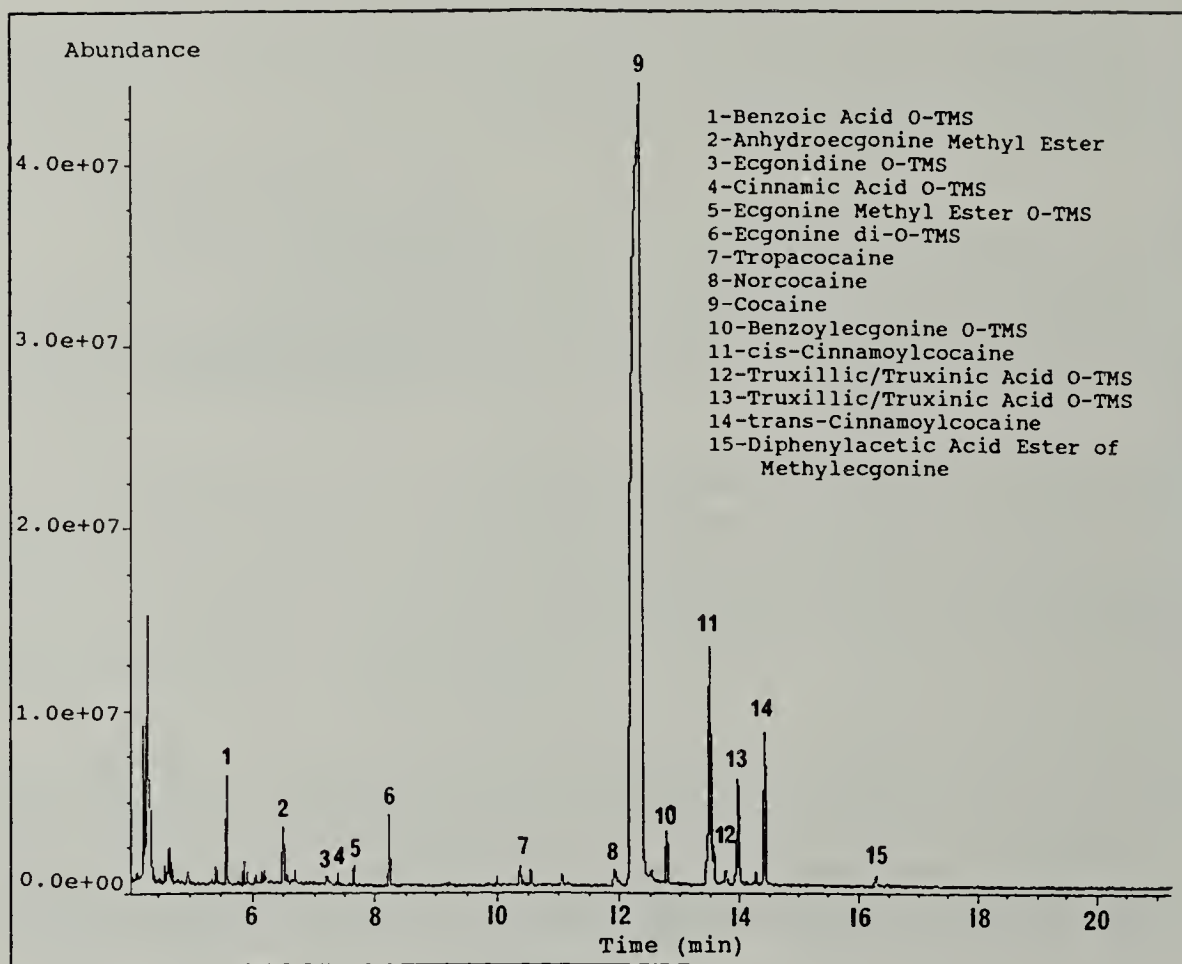


Figure 6

## THE 4-ANILIDOPIPERIDINE ANALGESICS<sup>a</sup>

Thomas N. Riley, Ph.D., Jack DeRuiter, Shridhar Andurkar  
*Department of Medicinal Chemistry*  
*School of Pharmacy*  
*Auburn University, AL 36849*

### INTRODUCTION

The favorable analgesic properties of the alkaloid morphine (Figure 1), a constituent of opium, were first shown in 1803. Further exploration of the pharmacological profile of morphine revealed this drug to be quite complex in its biological actions.<sup>1</sup> Table 1 summarizes the major pharmacological actions of morphine and related opiates. The pharmacological actions of these drugs translate into useful therapeutic effects including strong analgesia, cough suppression and an antidiarrheal action. The most troublesome unwanted effects of morphine and most opiates are constipation and respiratory distress. Therapeutic disadvantages in the chronic use of morphine includes poor oral bioavailability requiring administration of the drug by parenteral routes, the rapid development of tolerance (i.e. an increase in the dose needed to produce a given pharmacological effects) and dependence of both the physical and psychological types. Physical dependence to morphine and other opiates is characterized by the abstinence syndrome which is elicited upon abrupt withdrawal of opiate administration.

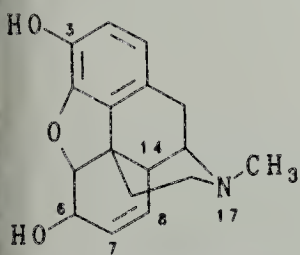


Figure 1. Morphine

Table 1. Pharmacological Profile of Morphine

- Analgesic
- Euphoria and sedation
- Respiratory depression
- Cough suppression
- Nausea and vomiting
- Constriction of the pupils of the eye
- Reduced gastrointestinal motility
- Bronchoconstriction
- Hypotension

<sup>a</sup>Manuscript received 11 September 1992; accepted 1 October 1992.

The pharmacologic and biopharmaceutic disadvantages of morphine served as the basis of a major research and development effort in an attempt to design useful therapy for the management of moderate to severe pain in patients.<sup>2</sup> Because of its favorable therapeutic properties, morphine served as the starting point in this development effort. Organic synthetic chemistry was in its infancy at the outset of this effort which limited structural modification of morphine to relatively simple changes in an attempt to improve its therapeutic profile. Hence, masking of the polar hydroxyl groups at C3 and C6 with lipophilic structural features (e.g.  $\text{CH}_3\text{CO}$  as in heroin) hastens the onset of action by improving distribution of the drug to the brain and may effect a separation of pharmacologic actions as in the case of the antitussive, codeine (e.g.  $\text{CH}_3$ ). Reduction of the C7,8 double bond and/or oxidation of the C6 hydroxyl group (e.g. hydromorphone) was found to significantly increase analgesic potency as did the introduction of hydroxyl at C14 (e.g. oxymorphone). Interestingly, replacement of  $\text{CH}_3$  at N17 with an allyl (naloxone) or bioisosteric cyclopropylmethyl substituent introduces an antagonistic component of pharmacologic action in these compounds (Figure 2).



Figure 2.

Addition or deletion of cyclic structural features from the morphine molecule leads to highly potent analgesics which, when substituted at N17 with structural features that impart antagonistic activity, exhibit reduced abuse liability (Figure 3). More extensive modification of the morphine structure leads to bicyclic 4-phenylpiperidines and 4-anilidopiperidines, 4-AP) and monocyclic (diphenylpropylamines, basic anilides) derivatives having a variety of therapeutic advantages (Figure 4).

The 4-AP group of synthetic opiates has served as the focus of our research group since 1970. Compared to morphine, the prototype 4-AP, fentanyl (Figure 4, 2:  $\text{R}'=\text{C}_2\text{H}_5$  and  $\text{R}=\text{CH}_2\text{CH}_2\text{C}_6\text{H}_5$ ), exhibits a faster onset and shorter duration of highly potent narcotic analgesia. Further, fentanyl has stronger sedative actions



## The 4-Anilidopiperidine Analgesics

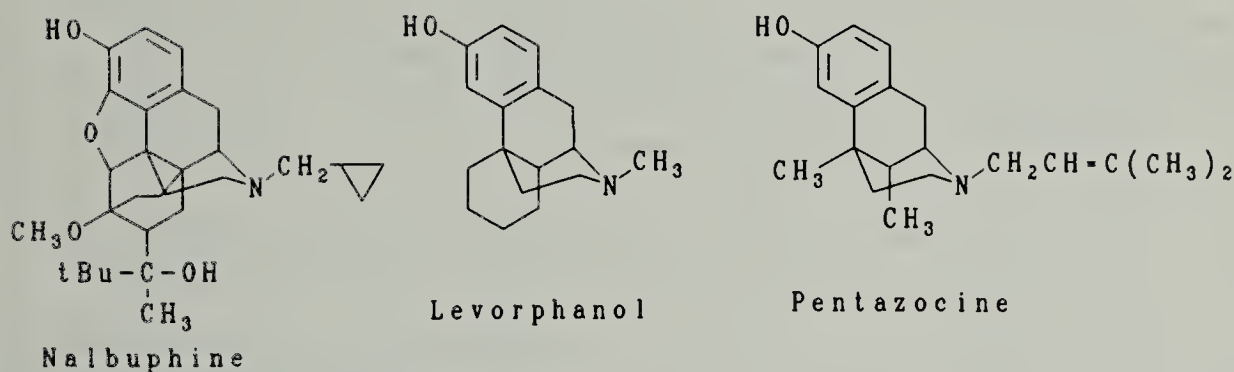


Figure 3.

leading to its use as a surgical pre-medicant. In addition to producing strong analgesia, the relatively simple 4-AP structure facilitates the performance of structure-activity relationship studies.<sup>3</sup> Structural modification of the 4-APs has yielded a number of derivatives that possess selected pharmacologic and/or biopharmaceutic advantages (Table 2).

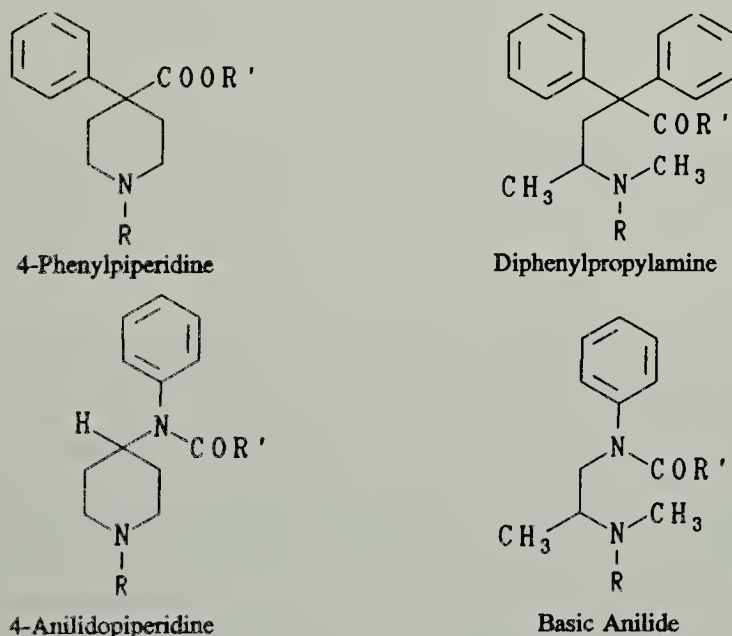
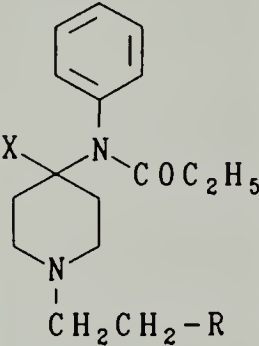
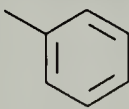
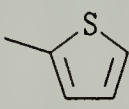
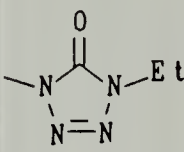
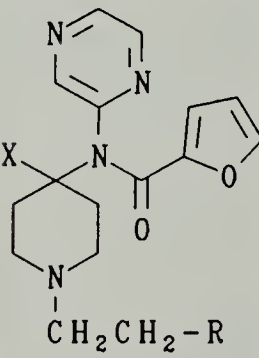
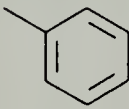


Figure 4.

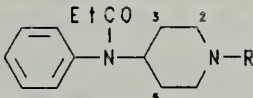
Table 2. 4-Anilidopiperidine Analgesics

STRUCTURE	R =	X =	DESCRIPTION
	  	COOCH <sub>3</sub>  CH <sub>2</sub> OCH <sub>3</sub>  CH <sub>2</sub> OCH <sub>3</sub>	<b>Carfentanil</b> — More potent and longer acting than fentanyl.  <b>Sufentanil</b> — More potent, longer acting and greater cardiovascular safety than fentanyl.  <b>Alfentanil</b> — More rapid onset, shorter duration of action than fentanyl.
		H	<b>Mirfentanil</b> — possesses opiate antagonistic properties and has a high degree of cardiorespiratory safety.

The primary thrust of our research has been to attempt to elucidate the structural and stereochemical features that are important in determining the pharmacological profile of a particular 4-AP analgesic. Our initial study in this regard involved a structure-activity relationship study of the influence of piperidine ring methylation on analgesic potency<sup>4</sup>. Previous studies indicated that methylation of the carbon  $\beta$  to the basic nitrogen in the 4-phenylpiperidine series (e.g. meperidine, R' = C<sub>2</sub>H<sub>5</sub> and R = CH<sub>3</sub>) yielded highly potent analgesic derivatives whereas methylation  $\alpha$  to the basic nitrogen in the basic anilide series was associated with highest analgesic potency. Hence, we designed, synthesized and measured the analgesic potencies three series of methylated 4-AP derivatives (Table 3) finding that monomethylation  $\beta$  to the ring nitrogen of the 4-AP produces a significant increase in analgesic potency while methylation at other ring carbons leads to a reduction in potency.

## The 4-Anilidopiperidine Analgesics

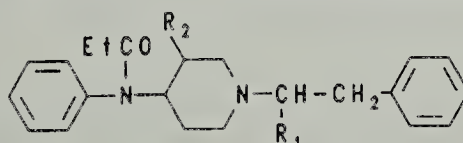
**Table 3. Analgesic Activities of Methylated 4-Propananilidopiperidines**

			
ED <sub>50</sub> , mg/kg IP in rats			
R =	2-CH <sub>3</sub>	3-CH <sub>3</sub>	2,5-diCH <sub>3</sub>
CH <sub>3</sub>	Inactive	14.34	Inactive
C <sub>6</sub> H <sub>5</sub> CH <sub>2</sub>	Inactive	36.67	65.14
C <sub>6</sub> H <sub>5</sub> CH <sub>2</sub> CH <sub>2</sub>	0.665	0.004	0.803

*ED<sub>50</sub> fentanyl HCl = 0.04 mg/kg i.p. in rats*

Introduction of substituents on the ring carbons of the 4-APs, except for the 4-position, yields stereoisomeric derivatives displaying both geometric and optical isomerism. It is well established that opiate receptor(s) display a relatively high degree of stereoselectivity when exposed to stereoisomeric ligands. Approximately one year after our report on the methylated 4-APs, Janssen and coworkers published the results of their study of similar methyl-substituted derivatives of fentanyl including the isolation, characterization and testing of individual stereoisomers (Table 4).<sup>5</sup> Consistent with the findings of our group, Janssen, et al. noted that introduction of a methyl group in the 3 position of the piperidine ring of fentanyl enhances analgesic activity. While the *trans* 3-methyl compound is somewhat more potent than fentanyl, the *cis* diastereomer is ~8 times more active than the parent analgesic. Analgesic activity of the *trans* isomer resides primarily in the (+)-enantiomer (3*S*,4*R* configuration).

**Table 4. Analgesic Activity of Methyl-Substituted Fentanyl Derivatives<sup>5</sup>**

			
R <sub>1</sub>	R <sub>2</sub>	Stereochem	ED <sub>50</sub> mg/kg iv in rats
H	H	—	0.011
CH <sub>3</sub>	H	(±)	0.0085
H	CH <sub>3</sub>	(±)- <i>cis</i>	0.0018
H	CH <sub>3</sub>	(-)- <i>cis</i>	0.068
H	CH <sub>3</sub>	(+)- <i>cis</i>	0.00058
H	CH <sub>3</sub>	(±)- <i>trans</i>	0.0094



It is of interest to note that the research on methylated derivatives of fentanyl led to the introduction of the first fentanyl designer drug in the United States. The abused substance *China White* was initially identified incorrectly as 3-methylfentanyl by the Drug Enforcement Administration, however more thorough analysis revealed that the active ingredient in China White is the side chain methylated derivative,  $\alpha$ -methylfentanyl. Since the first detection of  $\alpha$ -methylfentanyl in 1980, numerous designer drug derivatives of the 4-APs, including the 3-methyl analogue, have been produced in clandestine laboratories and distributed throughout the United States.

In view of the important role of geometric and optical isomerism in the analgesic activity of the 4-APs as exemplified in the 4-methyl derivatives, a study was undertaken to evaluate the role of conformational isomerism. The objective of this study was to identify the *pharmacophoric* conformation of the 4-AP moiety, that is, the shape of this structural feature that is most conducive to the production of a high analgesic response. Because the 4-anilidopiperidine moiety is relatively flexible conformationally, the intramolecular disposition of key structural features relative to an effective receptor interaction (Figure 5) was of interest. An indirect method of studying pharmacophoric conformations of biologically active substances involves the design of conformationally semirigid analogues that, upon interaction with the target receptor, present identical key structural features as in the case of the parent ligand. The tropane ring system was selected to impart conformation semi-rigidity in the piperidine ring of the 4-APs. Hence, identically N-substituted 3 $\alpha$ - and 3 $\beta$ -tropane analogues (Figure 6) were synthesized and characterized analgesically as conformational models of the axial and equatorial conformers of the 4-APs, respectively (Table 5).<sup>6</sup>

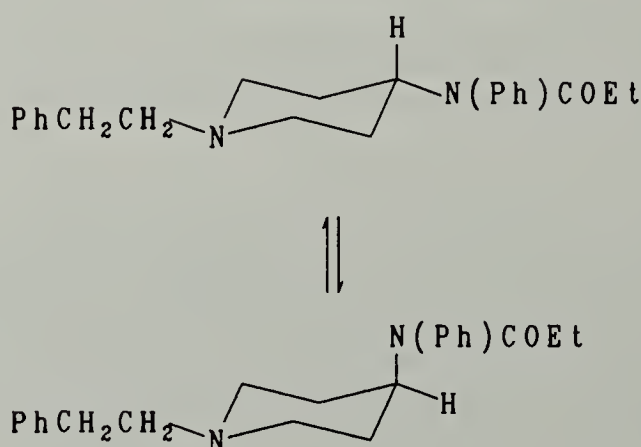


Figure 5.

## The 4-Anilidopiperidine Analgesics

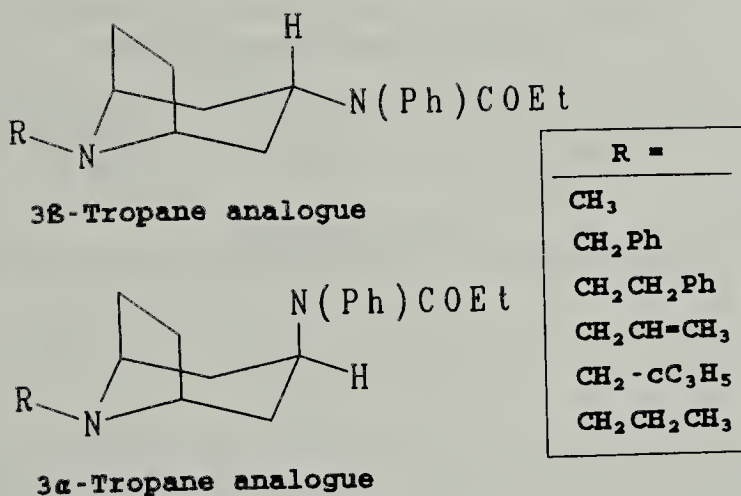


Figure 6.

The results of this study are consistent with previous structure-activity relationship studies of the 4-APs in that measurable analgesic activity is largely confined to those derivatives possessing an N-aralkyl (benzyl or phenethyl) substituent attached to the ring nitrogen atom. A definite stereochemical influence on analgesic potency of the tropane analogues was noted in that the 3β-isomers were significantly more potent than the corresponding N-substituted 3α-isomers. Relative solubilities (log P) of the tropane analogues were also determined in this study since it is possible that solubility differences can account for observed potency differences as a result of differential translocation into the CNS. However, while high analgesic activity of these 4-APs appears to be restricted to those analogues having a log P  $\geq$  3.15, the data support a dominant role for stereochemical factors affecting analgesic potency given the inverse relationship between relative solubilities and analgesic activities of the 4-APs. Hence, a pharmacophoric conformation of fentanyl was proposed based upon results of studies that elucidated stereochemical and structural requirements for 4-AP analgesic activity (Figure 7). The proposed conformation involves an extended 2-phenylethyl substituent attached to N1, a chair conformation for the piperidine ring, equatorial orientation of the propananilido substituent and pseudoaxial orientation of the phenyl group attached to the anilide N. The pharmacophoric conformational model also proposes that the anilide phenyl group is twisted so that its plane bisects that of the N1→C4 plane through the piperidine ring.

Attachment of substituents such as allyl and cyclopropylmethyl to the basic nitrogen atom of classical morphine-type opiates results in the development of an opiate receptor antagonist or partial agonist. However, similar structural modification of the 4-APs failed to elicit antagonistic activity. Subsequent studies by Bagley, et al. have revealed that more substantial structural modification of the 4-AP moiety must be performed in order to develop compounds with antagonistic activities as exemplified by mirfentanil.<sup>3</sup>

Table 5. Analgesic Activities of Isomeric N-Substituted 3-(Propananilido)nortropane Analogues

N-Substituent	log P	AD <sub>50</sub> , mg/kg sc (95% CL)
<b>3<math>\alpha</math>-Propananilides</b>		
H	2.71	> 100
CH <sub>3</sub>	2.82	> 100
CH <sub>2</sub> C <sub>6</sub> H <sub>5</sub>	3.95	35.5 (22.2-56.8)
CH <sub>2</sub> CH <sub>2</sub> C <sub>6</sub> H <sub>5</sub>	3.90	2.22 (0.92-5.33)
CH <sub>2</sub> CH=CH <sub>2</sub>	3.04	> 100
CH <sub>2</sub> - <i>c</i> -C <sub>3</sub> H <sub>5</sub>	2.95	> 100
CH <sub>2</sub> CH <sub>2</sub> CH <sub>3</sub>	2.94	> 100
<b>3<math>\beta</math>-Propananilides</b>		
H	2.52	> 100
CH <sub>3</sub>	2.70	> 100
CH <sub>2</sub> C <sub>6</sub> H <sub>5</sub>	3.30	1.80 (0.78-4.14)
CH <sub>2</sub> CH <sub>2</sub> C <sub>6</sub> H <sub>5</sub>	3.35	0.047 (0.017-0.131)
CH <sub>2</sub> CH=CH <sub>2</sub>	2.71	> 100
CH <sub>2</sub> - <i>c</i> -C <sub>3</sub> H <sub>5</sub>	2.67	> 100
CH <sub>2</sub> CH <sub>2</sub> CH <sub>3</sub>	2.70	> 100
Fentanyl citrate	3.15	0.024 (0.014-0.043)
Morphine sulfate	—	1.90 (1.29-2.79)

The influence of ring size on the analgesic activity of several structural classes of synthetic opiates have been widely studied. In particular, studies of perhydroazepine analogues of the 4-phenylpiperidines yielded clinically useful



## The 4-Anilidopiperidine Analgesics

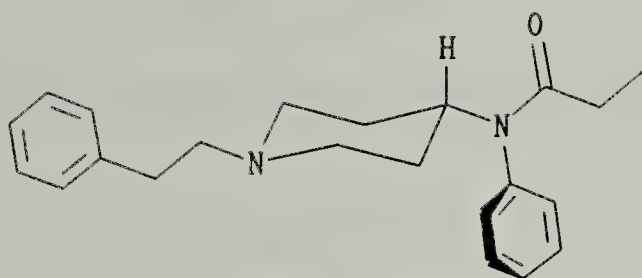
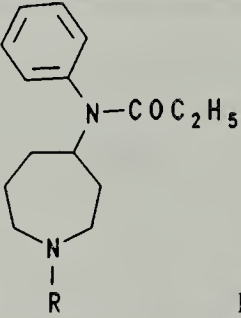


Figure 7.

analgesics of moderate potency accompanied by favorable therapeutic indices. A number of these ring expanded analogues also possessed reduced addiction liability and physical dependence capacity. In 1980, we undertook the synthesis and pharmacological evaluation of perhydroazepine analogues (Table 6) of the 4-APs reasoning that these analogues may retain a substantial degree of analgesic activity along with a favorable separation of desired and undesired activities.<sup>7,8</sup> In addition, chirality of the 4-anilidoperhydroazepines will permit separation of enantiomers and possible enhancement of opiate analgesic potency through stereoselectivity of receptor activity.

The results of this study indicated that ring-expanded homologues of the highly potent 4-APs retain a substantial level of analgesic activity. In fact, selection of the appropriate N1-substituent, e.g. PhCHOHCH<sub>2</sub>, yields an analogue whose analgesic potency is not statistically different from that of the prototypic 4-AP, fentanyl. Subsequent studies of the 4-anilidoperhydroazepines in mice revealed that they possess significant levels of physical dependence capacity. Studies are continuing in our laboratory in regard to investigating the influence of configurational isomerism on the opiate activity of these ring-expanded homologues.

Table 6. Analgesic Potencies of 4-Anilidoperhydroazepines

<div style="text-align: center;">  </div> <div style="display: flex; justify-content: space-between; margin-top: 10px;"> <span><b>R =</b></span> <span><b>ED<sub>50</sub>, mg/kg, sc (95% CL)</b></span> </div>	
CH <sub>3</sub>	11.6 (9.2-14.6)
CH <sub>2</sub> C <sub>6</sub> H <sub>5</sub>	3.6 (2.5-5.3)
CH <sub>2</sub> CH <sub>2</sub> C <sub>6</sub> H <sub>5</sub>	1.5 (0.9-2.6)
CH <sub>2</sub> =CHCH <sub>2</sub>	81.0 (66.1-99.2)
CH <sub>2</sub> - <i>c</i> -C <sub>3</sub> H <sub>5</sub>	>200
CH <sub>2</sub> -CHOH-C <sub>6</sub> H <sub>5</sub>	0.13 (0.071-0.25)

## The 4-Anilidopiperidine Analgesics

### REFERENCES

1. H. P. Rang, M. M. Dale, *Pharmacology*. Churchill Livingstone, New York, 2nd edition (1991).
2. Hite, G. J. 1989. Analgesics. In, W. O. Foye (eds.), *Principles of Medicinal Chemistry*, Lea and Febiger, Philadelphia, PA pp. 239-276.
3. Bagley, J. R., Kudzma, L. V., Lalinde, N. L., et al. 1991. Evolution of the 4-anilidopiperidine class of opioid analgesics. *Medicinal Research Revs* 11:403-436.
4. Riley, T. N., Hale, D. B., Wilson, M. C., 1973. 4-Anilidopiperidine Analgesic I: Synthesis and Analgesic Activity of Certain Ring-Methylated 1-Substituted 4-Propananilidopiperidine. *J. Pharm Sci* 62:983-986.
5. Van Bever, W. F. M., Niemegeers, C. J. E., Janssen, P. A. J., 1974. Synthetic Analgesic. Synthesis and Pharmacology of the Diastereoisomers of N-[3-Methyl-1-(2-phenylethyl)-4-piperidyl]-N-phenylpropanamide and N-[3-Methyl-1-(1-methyl-2-phenylethyl)-4-piperidyl]-N-phenylpropanamide. *J Med Chem* 17:1047-1051.
6. Riley, T. N., Bagley, J. R., 1979. 4-Anilidopiperidine Analgesics. 2. A Study of the Conformational Aspects of the Analgesic Activity of the 4-Anilidopiperidines. Utilizing Isomeric N-Substituted 3-(Propananilido) nortropane Analogues. *J Med Chem* 22:1167-1171.
7. Finney, Z. Gail, Riley, T. N., 1980. 4-Anilidopiperidine Analgesics. 3. 1-Substituted 4-(Propananilido) perhydroazepines as Ring-Expanded Analogues. *J Med Chem* 23:895-899.
8. DeRuiter, Jack, Andurkar, Shridhar, Riley, Thomas N., Walters, Donald E. Noggle, F. Taylor, 1992. Investigation of the Synthesis and Analgesic Activity of 1-Substituted 4-(Propananilido) perhydroazepines. *J Heterocyclic Chem* 29: 779-786.



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 Lumpkin, Rebecca N.  
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 Nance, C. Roger  
 Oths, Kathryn  
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 Rowe, Bobby  
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## Notes

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